POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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Cover: Boiler room of James Reed Station of the Duquesne Light Company, on Brunot's Island in the Ohio River. Single ended Westinghouse strokers 23 ft. long, five boilers producing 300,000 lb. of steam per hr. on base load service.

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A. W. KRAMER, Electrical Editor RICHARD H. MORRIS, Engineering Editor.

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FROM THE "VALLEY of HELL"

IN NORTHERN ITALY in a region known as the Larderello section is a strange valley which has come to be known as the "Valley of Hell." It is so called because it is a great source of subterranean steam. In this valley some 300 live steam wells have been tapped to provide steam for producing nearly 1,200,000 kw-hr. of electrical energy daily.

These steam wells are sometimes 1000 ft. deep and require as much as a year to drill. Although the source of power has been known of for nearly a hundred years it has been only in the last few years that engineers have succeeded in capitalizing on the supply. Lacking coal resources and oil reserves, Italy has been forced to utilize all its other material resources to provide electricity for its expanding industrial program.

This is the only place in the world where man has harnessed and controlled the power of underground volcanoes. Steam for electricity is not the only output of this "Valley of Hell." More than 8,000,000 tons of chemical products; pure borax, carbonic acid, ammonia, boric acid and other useful products are furnished as by-products of this steam power development.

In the above photograph are shown a group of giant condensation towers at one of the new turbine plants in the valley. Each of these towers is larger than the Tower of Pisa, which could be placed inside. Here natural steam, piped from the wells, is condensed into water. This water is then purified and again converted into pure steam by the heat of the live steam from the steam wells, which issues from the earth at about 220 deg. F. The pure steam is used in the turbo-generators. Each of these towers holds 30,000 cu. meters of water.

The completion of the eighth in a series of huge turbine plants early this year provides a capacity of approximately 32,800,000 kw-hr. of electrical energy per month. Almost all the industrial, railroad, and domestic consumption of electricity in northern Italy is met by production of power from this natural steam source.

WITH THE EDITORS

Health and Comfort from the Power Plant

AIR CONDITIONING service for summer weather is only a few years old but its popularity has advanced with extreme rapidity and no building, in a locality where heat becomes oppressive, can be considered modern unless provision is made to cool as well as heat portions of the building occupied by people. Complete air conditioning also includes ventilation, the removal of dust particles, poisonous or obnoxious gases, and humidifying to the most healthful degree. In other words, heating engineers have now available equipment with which it is practicable to surround people with air that is pure and comfortable.

In the conditioning of air, engineers have been guided principally by the comfort afforded the average occupant of the space heated or cooled. To ascertain just what temperature and humidity is best for various classes of workers has been one of the most difficult and long-standing problems of the industry but standards are now available and reports from installations where such standards are maintained indicate that this problem has been successfully solved.

In the final analysis, the degree of health of occupants of air-conditioned buildings before and after cleaning, cooling and humidifying were applied is the determining factor in the success or failure of an installation. The answer comes from W. B. Henderson, executive vice president of the Air Conditioning Manufacturers' Association, that illness of office employes in air-conditioned buildings has been reduced 28 per cent based on the average of days absent from work. To substantiate this figure he has compiled statistics from many sections of the country from the east coast to Texas, extending over periods up to six years. Medical authorities state that the incidence of respiratory ailments in winter is minimized because a properly humidified atmosphere increases the resistance of the mucous membrane of the nose and throat infection. Compiled data show that, although summer months are the healthiest of the year, a worker's chances of being laid up during this season are reduced by 60 per cent through the use of air conditioning.

Comfort service is becoming year by year an added load on power plants. Steam for heating is a traditional power-house load; ventilating takes electric or steam power; air washing adds pumping to the power load; electric precipitators take current; refrigeration for all kinds of cooling purposes is a rapidly growing electric or steam load.

To all of these items, which have to do principally with atmospheric conditions, add the comfort afforded occupants of buildings by lighting, water for all purposes, electric fans, elevator service and the thousand-and-one electric power driven appliances that relieve people of arduous tasks, and the importance of the power plant as a dispenser of comfort is very much in evidence.

The electric utilities have popularized many of these services, stressing particularly those that tend to even up the daily and yearly load curves, and the results have been highly beneficial. With the impetus given to certain lines of service by the utilities, the possibilities of expanding the services of power plants in buildings, institutions and factories have been greatly increased, particularly is this true of air conditioning in the summer time, and with the engineering data now available, specific studies can readily be made.

Why Engineers Behave Like Machines—If They Do

WHAT MAN can gaze on and contemplate the movements of a large Corliss engine or pumping engine for fifteen minutes without a feeling that here is a contrivance that follows laws to the letter? He sees in it something substantial, reliable, admirable; the load comes and goes, the governor collapses or expands to meet the emergency but the speed keeps up the rhythm without change perceptible to human senses. Multiply this speed of the engine by hundreds and you get the hum of the turbine following laws much more accurately than the engine.

Coal is fed into a furnace under so accurate a control that the variation in steam pressure, even under great swings in load, is barely readable on the indicating instruments. Here, again, invariable laws are in evidence; they must be obeyed; they command respect.

Structural parts, with the knowledge of material and mathematics available, are designed with such accuracy that the point of failure can be closely predicted, thus giving safety and confidence in the use of metals for various purposes.

Complicated though the design of electrical machinery and appliances may be, when the laws of physics, chemistry, metallurgy and other basic sciences are strictly observed, the speed, voltage, current, power, losses, temperature and other conditions incident to operation can be definitely predicted by the expert designer.

Would it be surprising, then, that the engineer, who is so accustomed to depending upon the absolute accuracy of his equipment and the natural laws under which it operates, should develop a philosophy of his own which tends to mold his character and behavior into qualities somewhat like the machinery he admires? In addition to being physical machines, all humans are thinking machines, their actions are guided by the conclusions of their thinking regardless of the correctness of their methods. Success in the application of physical laws is the result of logical thinking, call it machine thinking if you wish, the result is correct only when facts are used as premises and deductions follow with mathematical precision. More power to the man whose logic is as accurate as the operation of a modern machine.

WINNETKA'S NEW

WINNETKA is a residential suburb of Chicago, located on the west shore of Lake Michigan approximately twenty miles from the loop; at the present time the village has a population of 13,000. For many years this prosperous village has attracted attention because of the outstanding features of its civic life and more recently because it is the home of the present Secretary of the Interior, Harold L. Ickes. Its government, its progressive school system and its community house have attained for it more than local publicity, and the operation of its municipally owned electric and water plant, surrounded as it is by the great Public Service Co. of Northern Illinois system, has come in for a large share of interest. No small measure of the credit to which the plant owes its continued municipal existence must be attributed to the high plane on which the plant and the village have been operated. Partisan politics have been eliminated in the administration of municipal affairs and the village operates under the Council-Manager plan. The general management of the utilities is vested in an appointive city manager whose training and experience qualify him for this responsibility. Reporting to him is a superintendent of utilities, a graduate electrical engineer, formerly with a privately owned utility.

History

About the time the Village of Winnetka first attained a population of slightly over a thousand in 1891, the first constructive move towards the attainment of a modern water supply system was made, resulting in 1893 in the completion of the first pumping plant, water tower and distribution system, constructed largely under special assessment proceedings. In 1900, electric generating equipment was installed in the pumping station and electric service was made available for street lighting and for domestic and commercial consumption. Prior to that time no electric service was available in the community. From its beginnings, therefore, this plant has always been municipally owned and operated.

Since 1900 both the water and electric properties have been developed to meet the needs of the rapidly growing population of the village, all extensions being financed from surplus earnings with the exception of the water distribution system which has been constructed largely by special assessment and except a general bond issue of $86,000 to partially finance the construction of a filtration plant in 1922.

The water and electric plant is located at the base of a high bluff on the shore of Lake Michigan. This property which is attractively landscaped consists of a combined water pumping and filtration plant with an electric generating station all operated as a unit, with numerous resulting economies. The location is advantageous for electric generation, inasmuch as an ample supply of water is available from Lake Michigan for condensing purposes, although there is some disadvantage in the fact that direct deliveries of coal cannot be

ELECTRIC GENERATING PLANT

made by rail at this location, necessitating the trucking of coal for a distance of approximately one mile.

Meeting Growing Power Demand

Until the beginning of 1937 when the improvements described in this article were started, the plant had a capacity of 6250 kw. in turbogenerators operating at 225 lb. steam pressure with 100 deg. superheat. The turbine equipment was installed in two rooms, a south turbine room containing 3 units of 750, 1000, and 2000 kw. capacity respectively and served by jet condensers. In the north turbine room, the latest addition at that time, was installed a 2500 kw. turbine-generator with surface condenser but without extraction heating. The boiler room contained two 400 hp. and two 500 hp. water tube boilers, operated with chain grate stokers. The two 400 hp. units operated with natural draft and the two 500 hp. units were provided with forced draft equipment. A 200 ft. radial brick chimney served the boilers.

Some time previous to 1937 it became necessary to anticipate future maximum loads and to provide for a program of expansion which would insure sufficient generating capacity to carry these anticipated loads. A careful study of future maximum demands had been made by Frank F. Fowle & Co. in 1935 involving both increase in population and increase in use of electrical energy and these studies indicated maximum loads of 3550, 3800 and 4040 kw. for the years 1938, 1939 and 1940 respectively. While these were below the rated full load capacity of the plant, the general rule was that the plant capacity at all times had to be adequate to carry the maximum load with the largest electric generating and steam producing unit out of service. Furthermore any enlargement program had to take into account not only the immediate requirements but also future requirements over a period of at least 15 years. Consideration also had to be given to improvement in operating efficiency.

Byllesby Engineering and Management Corp. had made studies of possible methods of plant expansion in 1935 but due to restriction imposed by Federal legislation they were unable to continue handling outside work in 1936. Thereupon Sargent & Lundy, Inc., of Chicago, was retained to carry out the work.

After preliminary investigation and study, Sargeant and Lundy on Oct. 1, 1936, submitted a plan under which the expansion of the plant was finally carried out.

The plan called for a program of construction to be completed in three steps, the first step involving an expenditure of some $315,000 to be completed by

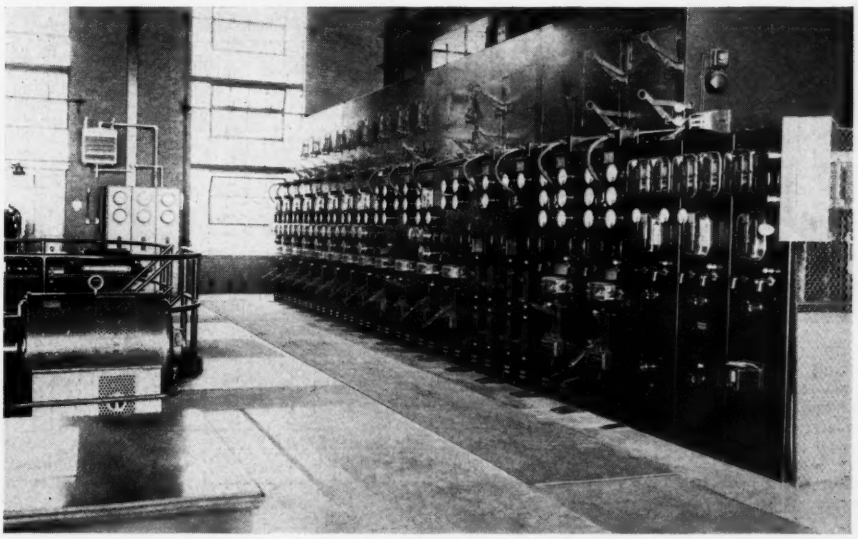
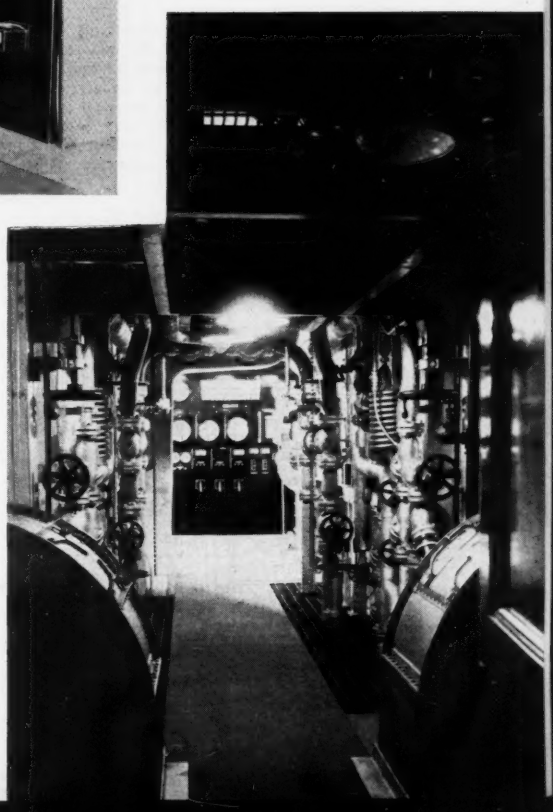


Fig. 1 (Extreme left). The new combustion control board

Fig. 2 (Left center). A general view in the turbine room

Fig. 3 (Right center). The main switchboard

Fig. 4 (Below). A view between the new boiler looking towards the boiler room



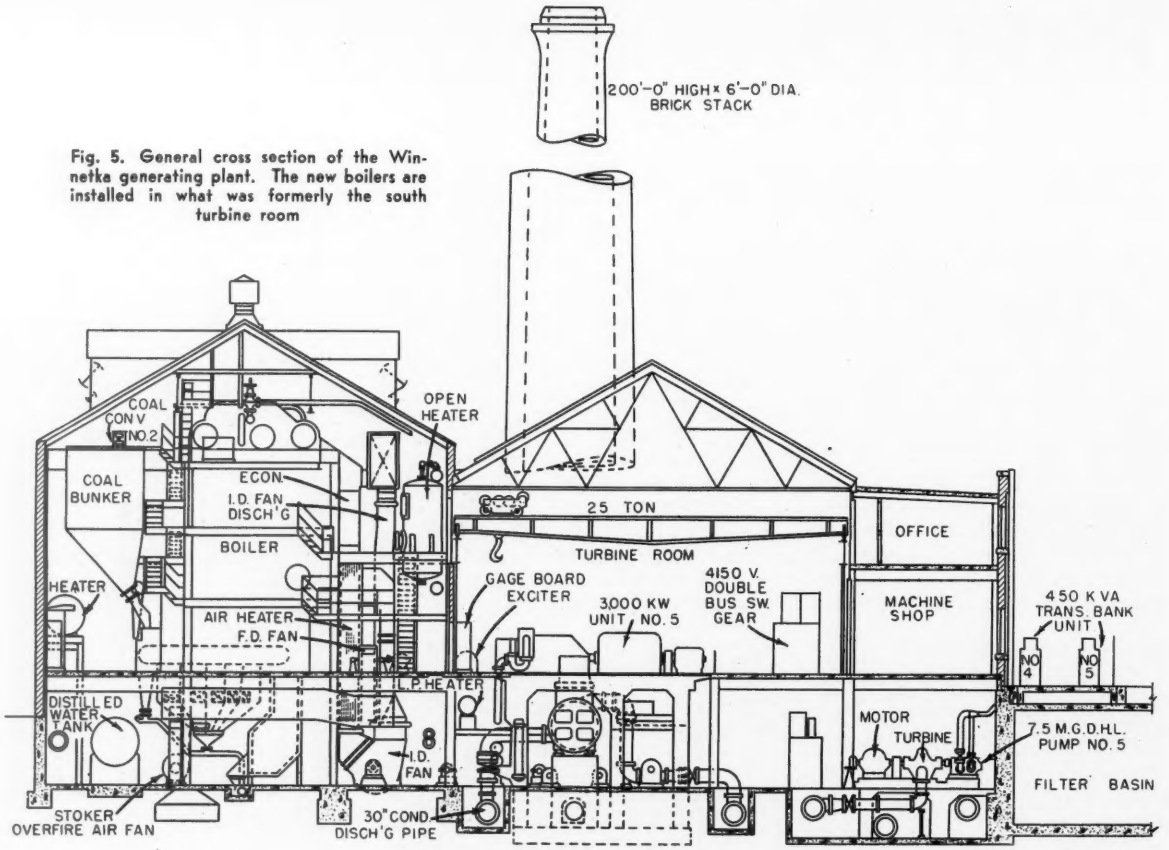


Fig. 5. General cross section of the Winnetka generating plant. The new boilers are installed in what was formerly the south turbine room

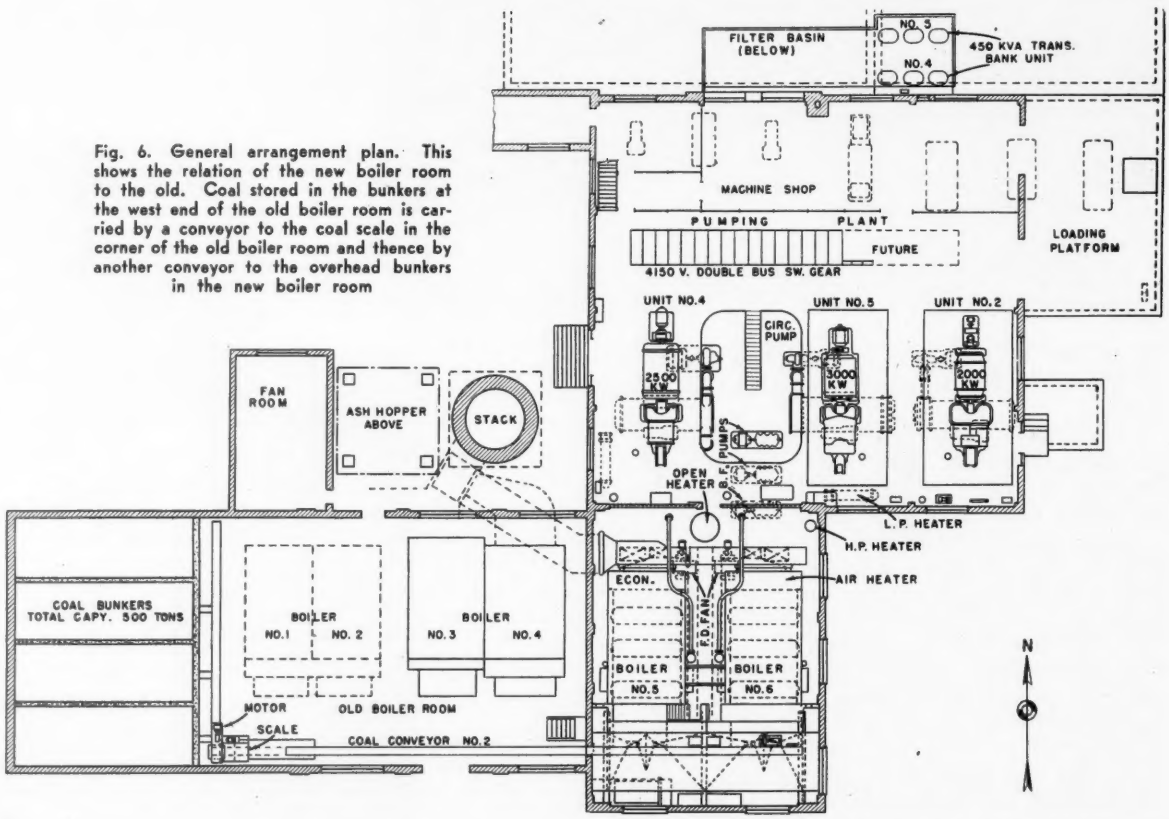


Fig. 6. General arrangement plan. This shows the relation of the new boiler room to the old. Coal stored in the bunkers at the west end of the old boiler room is carried by a conveyor to the coal scale in the corner of the old boiler room and thence by another conveyor to the overhead bunkers in the new boiler room

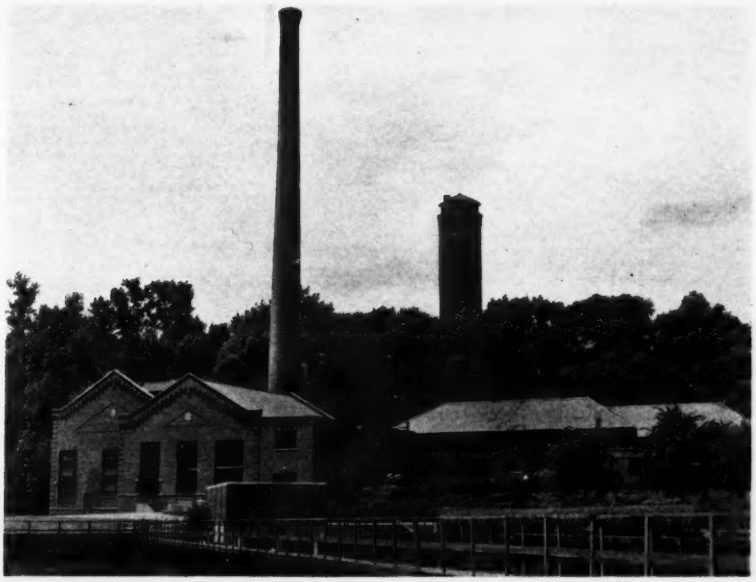


Fig. 7. An exterior view of the Winnetka Electric Plant and Pumping Station. It is situated on the shore of Lake Michigan at the foot of a high bluff

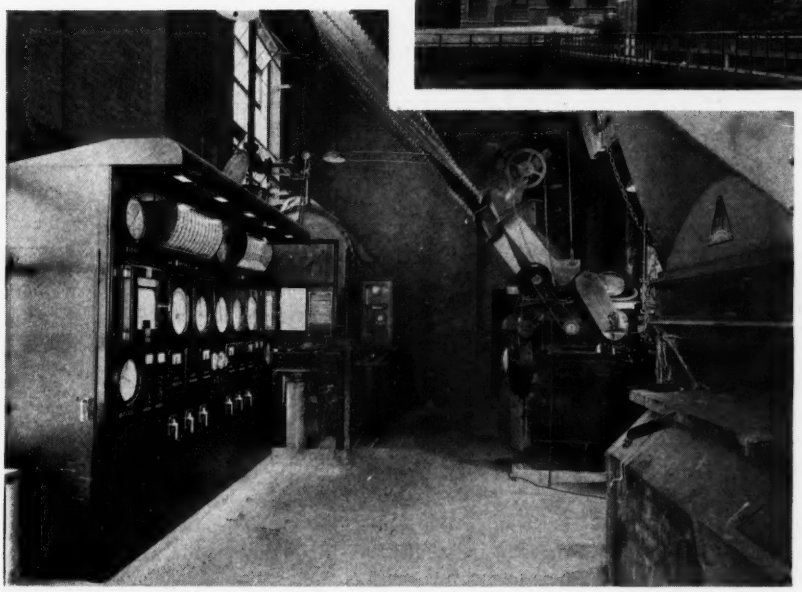


Fig. 8. A view in the new boiler room showing the stokers and the boiler control board. The stokers are motor driven through variable speed transmissions

December, 1937, in order to carry an estimated load of 3260 kw., the second with an estimated cost of $395,000 to be completed by December, 1938, in order to carry a load of 3550 kw., and a third step to be completed before December, 1943, in order to carry an estimated load of 4550 kw. The first two steps have now been completed, the work done providing the subject of this article.

Details of Expansion Program

Among other things the first step involved the following major elements:

(a) Install a (new) 3000 kw. turbogenerator (No. 5), condenser and auxiliaries; this unit built for 425 lb. steam pressure but operated for one year at 220 lb.

(b) Construct new combined waterworks intake and condensing water chamber.

(c) Extend new turbine room to provide space for relocated turbine unit No. 2 (a 2000 kw. machine installed in 1926).

(d) Install steam extraction equipment to be used in connection with unit No. 5.

(e) Remove turbogenerator unit No. 1.

It will be noted that this initial step involved no changes in the boiler plant. The new turbine (No. 5) as well as the old units (Nos. 2, 3 and 4) were to be operated on 220 lb. steam from the existing boilers.

With this step, the normal operation of the plant was on unit No. 5, which even at 220 lb. provided a better operating efficiency than unit No. 4. At this pressure, however, the unit would not carry over 2200 kw. but, according to the Westinghouse Co., the water rate at that load would not exceed 13 lb. per kw-hr. This was a considerably better water rate than that attainable by the older machines. The resulting net generating capacity under peak load conditions with this plan, assuming the largest unit out of service, was calculated as follows:

Unit No. 5...2000 kw. at 13 lb.	26,000 lb. steam
Unit No. 2...1400 kw. at 20 lb.	28,000 lb. steam
Total .....3400 kw.	54,000 lb. steam

This quantity of steam was within the maximum capacity of the, then, existing boiler plant with one of the 500 hp. boilers out of service.

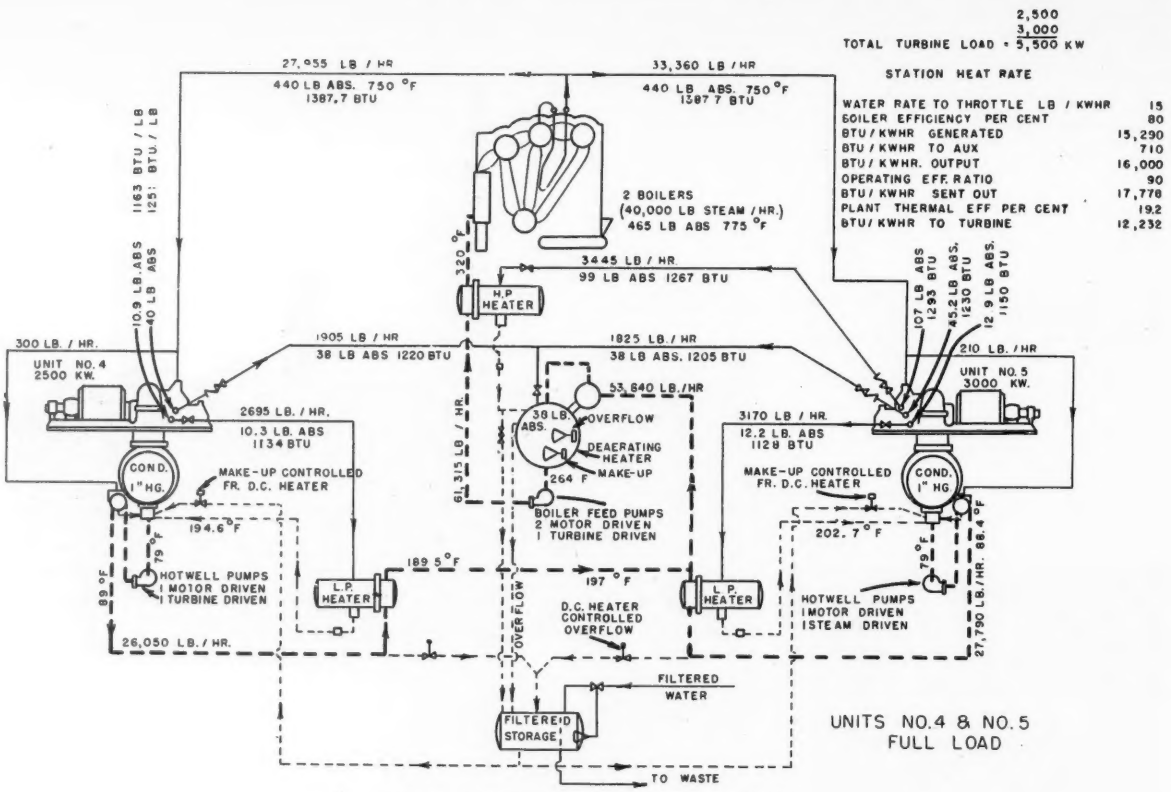


Fig. 9. Performance diagram for 5500 kw. load.

The construction program involved in "Step II" which was started immediately after "Step I" had been completed, included the following:

(a) Construction foundation for unit No. 2 which was to be relocated in the new turbine room.

(b) Equip unit No. 2 with surface condenser and move to new location.

(c) Remove unit No. 3 from old turbine room.

(d) Remodel old turbine room for use as a boiler room, extending east wall if necessary.

(e) Install two 40,000 lb. per hr. boilers for 450 lb. operation including necessary auxiliaries but using the existing stack.

(f) Rebuild No. 4 unit for 425 lb. operation, including installation of extraction equipment. The unit had been built in 1930 contemplating 400 lb. operation with minimum changes.

(g) Place units No. 4 and No. 5 in operation at 425 lb. pressure.

(h) Remove two 400 hp. boilers.

The resulting capacity of the plant after the work involved in these two steps had been completed was as follows:

Unit No. 2	2000 kw.	2 phase	220 lb.
Unit No. 4	2500 kw.	3 phase	425 lb.
Unit No. 5	3000 kw.	3 phase	425 lb.
Total	7500 kw.		

The New Plant

The arrangement of the plant at the present time, as a consequence of the completion of these two steps, is shown in Figs. 5 and 6 and in the accompanying photographs. The two new 40,000 lb. per hr. boilers are installed in the remodeled engine or turbine room to the east of the oil boiler room. The old boiler room still remains but boilers Nos. 1 and 2 have been removed. Boilers Nos. 3 and 4 are still in place but are not used.

The three turbines occupy the positions shown, the two 425 lb. units (Units Nos. 4 and 5) being located more or less in line with the new boilers, while unit No. 2, the old 220 lb. machine, occupies an adjacent position to the east. This unit of course operates from the 450 lb. steam line through a reducing valve and a desuperheater. All turbines now are served by surface condensers, the old jet condensers all having been discarded.

The new boiler room occupies, approximately, the position of the old south turbine room. The building was rebuilt, however, to accommodate the new boilers. As described in detail in the accompanying list of equipment, the two new boilers are B. & W. Stirling units having 5024 sq. ft. of heating surface, designed for 450 lb. pressure and with a rated steaming capacity of 40,000 lb. per hr. The units are set side by side with a passage between leading to the turbine room and they are fired by B. & W. forced-draft-chain grate stockers. Combustion is controlled automatically by a Hays system of combustion control designed for 110 v. a.c. service and a service water pressure of 70 lb. for operating the power cylinders. This system maintains constant steam pressure and controls the fuel feed, forced and induced draft fan dampers through the agency of water power cylinders. The combustion control board is located directly in front of and facing the boilers. It contains duplicate draft gages, pressure gages, water, steam and air flow meters for each boiler as well as the combustion control devices. The board

Equipment in the 1937-38 Installations at the Winnetka Electric Plant

GENERAL

LOCATION: Winnetka, Ill.

OWNER: The Village of Winnetka.

CONSULTING ENGINEERS: Sargent & Lundy, Inc.

STEAM GENERATING EQUIPMENT

STEAM GENERATING UNITS: Babcock & Wilcox Co. Two units each consisting of

BOILER: B. & W. Stirling. Class 31, No. 20. 5024 sq. ft. H.S. 450 lb. ga. at superheater outlet. Design press. 475 lb. at boiler drum. Steaming capacity, 40,000 lb. per hr. Scrubber in steam drum.

PERFORMANCE DATA:

Steam output lb./hr.	20,000	30,000	40,000
Superheater outlet pressure	450	450	450
Superheater outlet temp.	722	759	775
Excess air leaving boiler, %	50	40	30
CO_2 leaving boiler, %	12.35	13.35	14.3
Temp. flue gases leaving boiler	554	602	647
Temp. gases leaving economizer	467	513	551
Temp. gases leaving air heater	311	343	375
Temp. air entering heater	80	80	80
Temp. air leaving heater	270	281	292
Temp. water at econ.	320	320	320
Overall unit eff., %	84	84	82.9

SUPERHEATER: Pendant type, return tube. H.S. 2290 sq. ft.

ECONOMIZER: Forged steel, return bend. H.S. 513 sq. ft.

AIR HEATER: Vertical, tubular, H.S. 3455 sq. ft. 12 rows of 22 elements.

FURNACE: Bailey, water cooled. Area, each side wall, 64 sq. ft. Area, downtake wall, 177 sq. ft. Total area water cooled wall 305 sq. ft. Furnace volume 1340 cu. ft.

STOKER: B. & W. intermediate, forced blast chain grate. Effective area, 135 sq. ft. Size, 9'6" wide by 14'3" long. Five air compartments, bottom air admission.

STOKER MOTOR: General Electric, 3 hp., 1200 r.p.m., 440 v., 3 phase, 60 cycle squirrel cage.

STOKER DRIVE: Reeves variable speed transmission, 6 to 1 range.

AUXILIARY STOKER DRIVE: E. H. Wachs, 4 by 5 in. vertical center crank steam engine (relocated).

FUEL: Franklin county (Ill.) carbon, 11,600 B.t.u. or Macoupin county screenings, 10,995 B.t.u.

BOILER ACCESSORIES:

Water column wrought steel with 18¼ in. vision flat glasses. Diamond Power Specialty Corp.

Soot blowers. 5 for boiler. 2 for economizer. Diamond Power Specialty Corp.

Safety valves. Crosby Steam Gage & Valve Co.

Feedwater regulators. Copes. Northern Equipment Co., Inc.

Drumhead stop and check valves. The Edward Valve & Mfg. Co., Inc.

Blowoff valves. The Edward Valve & Mfg. Co., Inc.

Furnace arches. M. H. Detrick Co.

Boiler firebrick. A. P. Green "Empire".

Boiler exterior setting brick. Illinois red brick.

Boiler brickwork and arch erection. National Power Const. Co.

Boiler and boiler steel erection. Henry Pratt Co.

Economizer tube cleaner. Elliott Co.

FORCED DRAFT FANS: Two (one per boiler). Buffalo Forge Co. No. 5 SLD. 16 blade centerplate type rotator. Stationary inlet vanes driven by 20 hp. 1750 r.p.m., 440 v. Allis-Chalmers Mfg. Co. motors.

FORCED DRAFT FAN PERFORMANCE DATA: 5.03 in. static pressure.

Boiler steam output, lb./hr.	20,000	40,000	45,000
Cap. of fan, c.f.m., 100° F.	7500	13,500	15,400

INDUCED DRAFT FANS: Two (one per boiler). Buffalo Forge Co. No. 7½ SCLDD, 16 blade centerplate type, stationary inlet vanes. Driven by 40 hp. 1200 r.p.m. 440 v. Allis-Chalmers Mfg. Co. motors.

INDUCED DRAFT FAN PERFORMANCE DATA:

Boiler steam output	20,000	40,000	45,000
Cap. of fan, c.f.m.	10,900	21,500	25,000
Temp. of flue gas, deg. F.	311	375	392
Static draft developed in H_2O.	5.00	5.00	5.00

OVERFIRE AIR FAN: One. B. F. Sturtevant Co. No. 40, Planovane exhauster, overhung wheel. Driven by 7½ hp., 1160 r.p.m. 440 v. Allis-Chalmers Co. motor. Capacity of fan, 4000 c.f.m. Pressure increase from 3½ to 8 in. 4½ in. static pressure. Temp. of air, 250 deg. F. at 40,000 lb./hr. output.

COMBUSTION CONTROL EQUIPMENT

COMBUSTION CONTROL EQUIPMENT: The Hays Corp. Hays Automatic Combustion Control System designed for 110 volt a.c. service and service water pressure @ 70 lb. ga. Maintains steam pressure constant. Controls fuel feed, forced and induced draft fan dampers, and operates same by water power cylinders.

COAL HANDLING EQUIPMENT: Link-Belt Co. Capacity, 18 tons per hr. Conveyor No. 1 from storage bin to coal scale, 12 in. wide flight conveyor, driven by Allis-Chalmers 3 hp., 1750 r.p.m., 440 v., and speed reducer.

Conveyor No. 2 from coal scale to bunkers, 12 in. wide flight conveyor, driven by Allis-Chalmers 5 hp., 1150 r.p.m., 440 v., and speed reducer.

AUTOMATIC COAL SCALE: Richardson Scale Co. Coal scale capacity, 400 lb. dump, 18 ton per hr., driven by General Electric Co. motor.

MISCELLANEOUS BOILER ROOM EQUIPMENT

ASH CONVEYOR: "Steamatic," 8 in. United Conveyor Corp.

COAL VALVES: 4 (2 per blr.). Stock Engineering Co., by Faville-Levally Corp.

AUXILIARY STOKER DRIVE CONNECTIONS: Henry Pratt Co.

TURBINE AND CONDENSING EQUIPMENT

TURBO-GENERATOR, UNIT NO. 5: Westinghouse E. & M. Co. Consisting of: 1—3000 kw. 80 per cent power factor, 3600 r.p.m. single cylinder high pressure combination impulse reaction steam turbine. 1 Curtis stage, 35 pair reaction stages; 3 point extraction. Design conditions: 425 lb. sq. in. ga. 750° F. total temperature, 29 in. mercury vacuum. Maximum temperature 775° F. 1—3750 kv-a., 3000 kw. 80 per cent power factor A.C. generator, 3 phase 60 cycle, 2400/4150 v. 1—22 kw. 125 v. shunt wound direct connected exciter. 1—845 sq. ft. generator air cooler, designed for 80° F. cooling water. 1—105 sq. ft. oil cooler, ⅝ in. O.D. tubes. 1—Turbine driven auxiliary oil pump.

PERFORMANCE DATA:

Generator output, kw.	1500	2250	3000	3750
Power factor, per cent	80	80	80	100
Throttle flow (Non-extraction) lbs./hr.	15,195	21,690	28,230	35,288
Throttle flow (Non-extraction) lbs./kw-hr.	10.13	9.64	9.41	9.41
Full load extraction steam conditions: at		Point No. 1	Point No. 2	Point No. 3
Pressure, lbs. absolute		107	46	14.9
Heat content, B.t.u. per lb.		1293	1230	1153

ONE CONDENSING EQUIPMENT, UNIT NO. 5: Allis-Chalmers Mfg. Co. Consisting of: 1—4000 sq. ft. horizontal two-pass welded steel plate surface condenser. 1—Twin element two-stage steam jet air pump. 2—Hotwell pumps, two-stage centrifugal), 4 in. x 2 in., 85 g.p.m. against a total dynamic head of 195 ft., 1750 r.p.m. 1—Hotwell pump motor drive, Allis-Chalmers 15 hp. motor, 1750 r.p.m., 440 volt, 60 cycle, 3 phase. 1—Hotwell pump steam turbine drive, Terry impulse turbine, 12 hp., 1750 r.p.m., 450 lb. ga. steam. 1—Circulating water pump, size 16 in. x 14 in., horizontal centrifugal pump, 6000 g.p.m. against a total head of 25:5 ft. 1—Circulating water pump motor drive, Allis-Chalmers, 60 hp. motor, 690 r.p.m., 440 volt, 60 cycle, 3 phase.

TURBO-GENERATOR, UNIT NO. 4: Westinghouse E. & M. Co. Installed in 1930; rebuilt in 1938 for higher pressure. 1—2500 kw. 80 per cent power factor, 3600 r.p.m. single cylinder steam turbine. 2 point extraction. Rebuilt conditions: 425 lb. sq. in. ga., 750° F. total temperature, 29 in. mercury vacuum. 1—3215 kv-a., 2500 kw. 80 per cent power factor A.C. generator, 3 phase, 60 cycle, 2400/4150 v. 1—22 kw. 125 v., direct connected exciter. 1—turbine driven auxiliary oil pump.

PERFORMANCE DATA:

Generator output, kw.	1250	1875	2500	3125
Throttle flow (non-extraction) lb./kw-hr.	11.2	10.55	10.26	10.26
Throttle flow (non-extraction) lb./kw-hr.	14,000	19,782	25,650	32,065
Full load extraction steam conditions: at			Point No. 1	Point No. 2
Pressure, lbs. absolute			40	10.9
Heat content, B.t.u. per lb.			1251	1163

CONDENSING EQUIPMENT, UNIT NO. 4: Ingersoll-Rand Co. Installed in 1930. Consists of: One 4700 sq. ft. horizontal two-pass surface condenser; one steam jet air pump; two Allis-Chalmers hotwell pumps, type C2S, two stage centrifugal 85 g.p.m. against a total dynamic head of 195 ft., 1750 r.p.m. (Installed in 1937.) One hotwell pump steam turbine drive, Terry impulse turbine, 12 hp., 1750 r.p.m., 450 lb. ga. steam. (Installed in 1937.) One hotwell pump motor drive, Allis-Chalmers 15 hp. motor, 1750 r.p.m., 440 v., 60 cycle, 3 phase. (Installed in 1937.) One circulating water pump, Cameron No. 14, horizontal centrifugal, 5800 g.p.m. against 28 ft., 690 r.p.m.; one circulating water pump motor drive Westinghouse 50 hp. motor, 690 r.p.m., 440 v., 60 cycle, 3 phase.

TURBO-GENERATOR, UNIT NO. 2: Westinghouse E. & M. Co. Installed in 1926. Relocated in 1937 and surface condenser added. One 2000 kw. 80 per cent power factor 3600 r.p.m. steam turbine. Design conditions: 220 lb. sq. in. ga., 520° F. total temperature, 1.5 in. back pressure. One 2500 kv-a., 2000 kw. 80 per cent power factor A.C. generator, 2 phase, 3 wire, 60 cycle, 2400 v. Direct connected to system through Scott transformer for 3 phase distribution. One direct connected exciter; one Worthington oil pump.

ONE CONDENSING EQUIPMENT, UNIT NO. 2: Allis-Chalmers Mfg. Co. Installed in 1937. Consists of: One 3000 sq. ft. horizontal two-pass, welded steel plate, surface condenser. One twin element two stage steam jet air pump. One Cameron hotwell pump, two stage centrifugal. 85 g.p.m. at 90 ft. head, 1750 r.p.m. Relocated from Unit No. 4 where it was installed in 1930. One hotwell pump steam turbine drive, Terry 10 hp., 225 lb. ga. steam pressure, 1750 r.p.m. Relocated from Unit No. 4. One circulating water pump, size 16 in. x 14 in., horizontal centrifugal pump. 4500 g.p.m. against a total head of 25.5 ft. One circulating water pump motor drive, Allis-Chalmers 50 hp. motor, 690 r.p.m., 440 v., 60 cycle, 3 phase.

FEEDWATER HEATING EQUIPMENT 1937 AND 1938 INSTALLATION

ONE LOW PRESSURE CLOSED HEATER, UNIT NO. 5: Whitlock Coil Pipe Co. Horizontal, floating head type, 6 pass. Heating surface, 156 sq. ft. Heating capacity 30,000 lb. per hr. from 90° F. to 202° F. with steam at 13.5 lb. ab.

ONE LOW PRESSURE CLOSED HEATER, UNIT NO. 4: Whitlock Coil Pipe Co. Horizontal, floating head type, 6 pass. Heating surface 156 sq. ft.; heating capacity, 30,000 lb. per hr. from 90° F. to 190° F. with steam at 10.3 lb. ab.

ONE HIGH PRESSURE CLOSED HEATER, UNITS NO. 5 AND NO. 4: Whitlock Coil Pipe Co. Horizontal, floating head type, 4 pass. Heating surface, 215 sq. ft. Heating capacity, 65,000 lb. per hr. from 270° F. to 320° F. with steam at 99 lb. ab.

ONE DEAERATING FEEDWATER HEATER: The Hoppes Mfg. Co. Vertical, direct contact type. Heating surface, 193 sq. ft. Heating capacity, 75,000 lb. per hr. from 200° F. to 270° F. with steam at 42 lb. ab. Storage capacity, 133 cu. ft. Vent condenser, single pass, 65 sq. ft.

TURBINE DRIVEN BOILER FEED PUMP: One Ingersoll-Rand Co., Inc., horizontal centrifugal type, 6 stage, 80 g.p.m. at 3500 r.p.m. Suction head, 45 lb./sq. in. ga. Discharge head, 620 lb./sq. in. ga. Turbine drive, Terry 60 hp. at 3500 r.p.m., 425 lb. gauge steam, 725° F.

MOTOR DRIVEN BOILER FEED PUMPS: Two Ingersoll-Rand Co., Inc. Horizontal centrifugal 6 stage. Capacity, 80 g.p.m. at 3500 r.p.m. Suction head, 45 lb./sq. in. ga. Discharge head, 620 lb./sq. in. ga. Motor drive, 75 hp., 3550 r.p.m., 440 v., 60 cycle, 3 phase Allis-Chalmers.

TRAVELING WATER SCREENS: Chain Belt Co.

ONE TRAVELING SCREEN WASH PUMP: Yeomans Bros. Co.

SUMP PUMP: Yeomans Bros. Co.—Type, vertical.

PRIMING PUMP: Standard Power Equip. Co.—For priming screen wash pump suction pipe and crib house siphon. Type, Nash Hytor vacuum pump.

HEATING SYSTEM CONDENSATE RETURN PUMP: Chicago Pump Co.—Type, condensation unit with tank. Size, 1¼ in., 10,000 sq. ft. radiation equiv. Capacity, 15 g.p.m. at 50 lb. discharge.

HIGH LIFT PUMP EMERGENCY TURBINE: Terry Steam Turbine Co.—Type GS-21 single wheel; capacity, 300 hp. at 1200 r.p.m.

LOW LIFT FILTER PUMP: Worthington P. & M. Corp.—Pump, single stage; head, double suction 36 ft.; capacity, 5560 g.p.m.

Equipment in the 1937-38 Installations at the Winnetka Electric Plant—Continued

MISCELLANEOUS EQUIPMENT

PIPING SYSTEM: William A. Pope Company.
CIRCULATING WATER PIPING (OUTSIDE): U. S. Pipe & Foundry Co.
INSIDE WATERWORKS PIPING: Crane Co.
WATERWORKS VALVES: The Chapman Valve Mfg. Co.
ERECTION OF CIRCULATING WATER PIPING: William A. Pope Company.
FIVE SLUICE GATES: Crane Co.
CONDENSATE VENTURI METER: Builders Iron Foundry.
H. P. STEAM FLOW METERS: J. W. Murphy Company.
IND. PRESS. GAGES: Manning, Maxwell & Moore.
TEMP. & PRESS. RECORDER: Manning, Maxwell & Moore.
ONE ELECTRIC CLOCK: Manning, Maxwell & Moore.
IND. THERMOM. AND TEST WELLS: Precision Thermom. & Instru. Co.
MERCURY COLUMN VACUUM GAGE & BAROMETER: Precision Thermom. & Instru. Co.
TEMPERATURE RECORDERS: Leeds & Northrup Co.
DRAFT AND PRESSURE GAGES: J. W. Murphy Company.
CO_2 RECORDERS: J. W. Murphy Company.
PRESS. REDUC. & DESUP. EQUIP.: J. W. Murphy Company.
TURBINE ROOM GAGE BOARD: Central Arch. Iron Works.
TURBINE OIL STORAGE TANK: S. F. Bowser.
DISTILLED WATER TANK: Leader Iron Works.
DUCT WORK: Henry Pratt Company.
GENERATOR AIR DUCTS—Unit 2: Henry Pratt Company.
GENERATOR AIR DUCTS—Unit 5: Henry Pratt Company.
SMOKE FLUES AND UPTAKES: Henry Pratt Company.
MISCELLANEOUS STEEL AND IRON: Henry Pratt Company.
INSULATION: Smith-Totman Co.
INSULATION: Johns-Manville Sales Corp.
SMOKE FLUE AND AIR DUCT INSULATION: Johns-Manville Sales Corp.
SMOKE FLUE GUNITE LINING: Otto Randolph, Inc.
GENERAL BUILDING CONTRACTOR: Otto Randolph, Inc.
UNIT HEATER: Buffalo Forge Company.
PRESS. REDUC. VALVE: J. W. Murphy Company.
H. P. STEAM TO EXIST. PLANT DESUPERHEATER: J. W. Murphy Company.
IND. PRESS. GAGES AND RECORDING: Consolidated-Ashcroft Hancock Co.
EXTENSIONS TO ASH CONVEYOR: United Conveyor Corp.
MONEL METAL ORIFICES: Bailey Meter Co.

is symmetrically and attractively designed and well lighted.

Coal, mainly Illinois screenings, is delivered to the plant by truck to a concrete unloading platform at the top of the bluff from which it flows by gravity to 500 ton capacity bunkers at the west end of the old boiler room as shown on the plan view. A horizontal conveyor moves it from these storage bunkers to a Richardson automatic electric coal scale located on the floor in the southwest corner of the old boiler room. After being weighed, another inclined conveyor carries it to the two new overhead coal bunkers in the new boiler room which have a capacity of 45 tons each. From these bunkers the coal feeds by gravity to the stoker hoppers which are provided with Conical non-segregating coal distributors.

The stokers are driven, normally, by squirrel cage motors through Reeves variable speed transmissions but an auxiliary engine drive is provided for emergency use. This consists of a 4 by 5 in. E. H. Wachs vertical center crank steam engine mounted alongside one of the stokers on the operating floor but so arranged that it can drive the other stoker through a line shaft mounted on the ceiling of the floor below. The stokers are supplied with a separate source of overfire air, in the form of a single 400 c.f.m. fan located in the basement, this fan supplying both boilers. The forced draft to each of the stoker compartments can be varied independently, permitting a wide range in capacity and efficient combustion with different grades of coal.

The selection of stokers for this plant was desirable, not only because they are well fitted to burn the coal used, but also because, with stokers, the fly ash nuisance would be reduced to a minimum, a highly necessary factor in a high class residential community.

Forced draft is supplied by two fans, one for each boiler unit and located on the operating floor back of the boilers. The induced draft fans are located in the basement with the suction inlet directly below the outlets of the air preheaters as shown in the cross section, Fig. 5. These fans discharge the gases into a horizontal breeching in the upper part of the boiler room from which in turn they are delivered to the stack. Both the forced and induced draft fans are motor driven, operating at constant speed and with the combustion control regulators acting on the fan dampers.

Ash removed from the stoker ash hoppers in the basement is carried to an overhead ash hopper by means of a steam jet ash conveyor which was extended to include the new boilers in the 1937 construction program.

The general arrangement of the feedwater system is shown in Fig. 9. Water from the condenser hotwells is delivered by hotwell pumps associated with each condenser through the steam jet air pumps, through a low pressure extraction heater associated with each turbine to a 75,000 lb. per hr. Hoppes deaerating heater. From this heater the boiler feed pumps pump the water through a high pressure extraction heater to the economizer and then to the boilers. Three 6-stage boiler feed pumps are provided, each with a rating of 80 g.p.m. against a discharge head of 620 lb. per sq. in. Two of these units are motor driven while the third is turbine driven. These units are located on the condenser floor in the turbine room. The feedwater to the boilers is controlled by Copes feedwater regulators.

The Turbine Room

The arrangement of equipment in the turbine room is evident from the plan view of the station shown in Fig. 6. As already pointed out the three turbo-generating units are set with their shafts parallel to each other, the new 3000 kw. machine (No. 5) occupying the center position. Between this unit and unit No. 4 to the west is a large open areaway providing light and air to the condenser floor below.

The new generating unit is a 3600 r.p.m. Westinghouse machine driving a 2400/4150 v., 3 phase, 60 cycle, alternator with direct connected exciter and served by a 4000 sq. ft. Allis-Chalmers surface condenser.

Unit No. 4, also a Westinghouse unit, as provided for in the second step of the construction program was rebuilt to operate on 425 lb. steam pressure. It was installed in 1930 and originally designed for 220 lb. pressure .This unit is served by a 4700 sq. ft. Ingersoll-Rand condenser.

The remaining generating unit, No. 2, was installed in 1926 and was merely relocated and provided with a new surface condenser in the 1937 construction program. It still operates on 220 lb. steam pressure. A desuperheater and pressure reducing station is provided for supplying the old 220 lb. system from the new boilers.

The guaranteed performance data and other details of these machines is covered in the accompanying list of equipment and need not be elaborated on here.

Current is generated at 4000 v. and is delivered to a distribution system which consists partially of underground conduit and cable and partially standard overhead pole line construction. The 2 phase machine is connected to the system through a bank of Scott-connected transformers installed on the outside of the building.

The general appearance of the plant is pleasing. In the new boiler room the stokers, boiler fronts, duct work, the forced and induced draft fans and the boiler steel work are painted with aluminum paint. The interior walls are of red pressed brick. The floors, throughout the boiler and turbine rooms, are Kalman Finished concrete. A color code is employed in the painting of all equipment, piping, structural steel and switchboard equipment which not only aids in the identification of piping but presents a neat appearance. The ceiling of the turbine room and the new boiler room is covered with a $\frac{3}{16}$ in. Flexboard, fire proofing material, manufactured by the Johns-Manville Co. to comply with the rules of the insurance company for obtaining a preferred risk policy. This resulted in a considerable saving in insurance premium.

The construction work involved in this rehabilitation was completed well within the limits specified by the plans and at less than the original estimated costs. The total cost of the enlargement program as carried out during the period between 1936 and 1939 was $608,372.39. This was divided as follows:

1. Building and structures	$104,677.97
2. Plant Equipment	
(a) Boiler Plant Equipment	286,162.72
(b) Electric Plant Equipment	217,267.44
3. Shop Equipment	263.90
Total Power Plant	$608,372.03

The total cost of the entire plant enlargement project including improvements and additions to the water plant, was $711,995.29. This was a saving of $59,415.71 from the estimate of $771,411.00 made by the consulting engineers.

As a result of the improvements, the generating station now has a rated capacity of 7500 kw. and a total steam generating capacity of 138,000 lb. per hr. which should safely carry the load until at least the 1943 peak.

In raising the steam pressure from 225 lb. to 450 lb., the total temperature from approximately 500 deg. to 750 deg. F., an improvement of approximately 24 per cent in operating efficiency was effected. The fuel consumption per kw-hr. output was reduced from 2.32 lb. in 1937-38 to the present value of 1.92.

Sale of Power

The general policy of the Village, in the operation of this power system, is to maintain electric rate schedules which are on a par with the rates charged by the Public Service Co. of Northern Illinois to consumers in the neighboring towns and villages for similar service. In 1938 the Village made a rate reduction similar to that made by the Public Service Co. and this year, a further reduction in the rate was made, also in line with that of the surrounding utility company. Since 1928, rate reductions have aggregated 60 per cent.

The average cost per kilowatt-hour sold during the fiscal year ending March 31, 1939, was 2.03 cents. The unit costs involved in this figure are interesting and are as follows:

Item	Cost
Steam generation	0.55 cents
Electric generation	0.17 cents
Distribution	0.11 cents
Utilization	0.03 cents
Commercial	0.07 cents
New business	0.01 cents
General expenses	0.23 cents
Depreciation	0.62 cents
Distribution loss	0.15 cents
Total	1.94 cents
3% Utility Tax	.09 cents
Total cost per kw-hr. sold	2.03 cents

These costs do not include interest on property investment.

The average rate paid for electric service for all classes of power for the same period was 3.56 cents per kw-hr.

The average load factor on the plant for the year was 36.5 per cent.

The book value of the plant on March 31, 1939, was $1,807,113. Deducting accrued depreciation of $283,903 leaves a net depreciated value of $1,613,210.

With the exception of a few thousand dollars borrowed from the general village fund in 1900 when the electrtic generating plant was first established and which was subsequently repaid, the property has been financed entirely from earnings of the department without incurring bonded or other indebtedness.

The plant is operated under the supervision of C. R. Miller, Superintendent of Water and Electricity, to whom we are indebted for his courtesy and cooperation in supplying data for this article.

Transmission systems which connect to transmissions that cross state lines are subject to the jurisdiction of Federal Power Commission, according to a decision recently announced. This applies even though all lines of a utility company are in one state, if connection is made to lines of another company which transmit electric energy across a state boundary line. This gives the Commission power over stock issue and transfer as in the case of New Jersey Power and Light Co., which had acquired a block of Jersey Central Power and Light Co. without authorization by the Commission.

The latter company owns and operates lines all within New Jersey but connecting at the Raritan River to lines of the Public Service Electric and Gas Co. which in turn transmits to Staten Island in New York. Jersey Central Power and Light Co. is, therefore, ruled to be under jurisdiction of the Commission and acquisition of a major part of its capital stock without authorization of the Commission to be a violation of the Federal Power Act.

By use of characteristic curves, centrifugal pumps may be adapted to changed conditions without great reduction in efficiency

Centrifugal Pump Characteristic Curves

By K. B. HUMPHREY

EFFICIENT operation of a given centrifugal pump is not limited to a single point. In fact this type of pump lends itself remarkably well to any change in operating schedule within quite wide limits, and consequently it is seldom necessary to discard a pump because it no longer meets the exact requirements for the new conditions. That is, any given sized centrifugal pump can be made to operate with fair efficiency at different heads or capacities by combining the right speed and horsepower for the job.

Data Given on Characteristic Curves

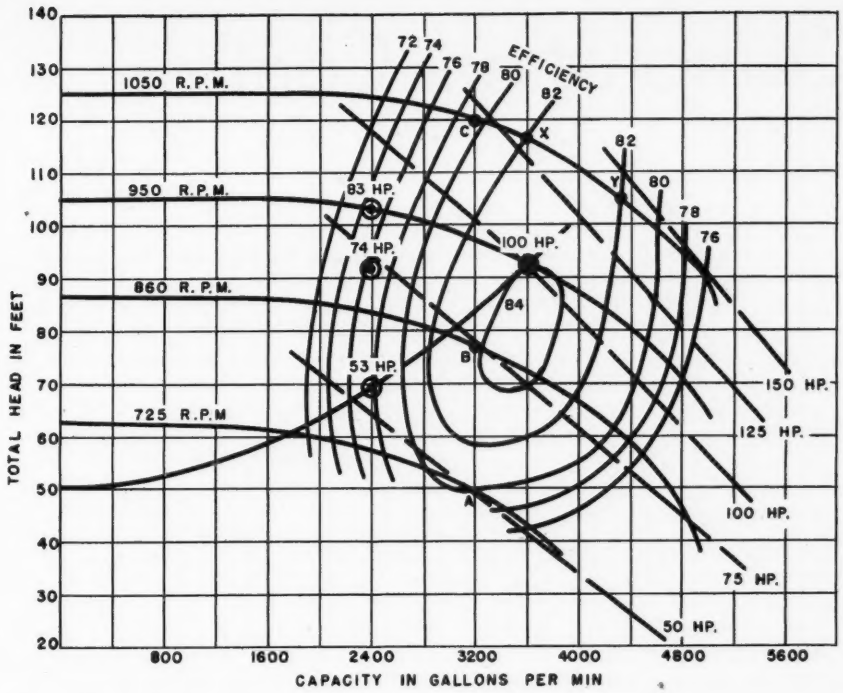
The best way in which to get an understanding of just what can be expected of a centrifugal pump operating under different conditions is to make a study of the characteristic curves. A typical set of curves are illustrated in the accompanying illustration for a 10-in. pump. Similar curves can be obtained for any other pump though naturally they will not be identical. Each individual pump design will produce its own set of curves. Referring to the curve sheet, the curves marked with the r.p.m. from 725 to 1050 (taken in steps corresponding to available motor speeds) show the relation of the total dynamic head in feet of water on the vertical scale against the discharge in gallons per minute on the horizontal scale. With a given constant speed the head drops off with increased capacity. The horsepower lines shown dashed are very nearly straight. The horsepower increases with an increase in head pumped against. The efficiency curves, superimposed on the same chart, are shown by a series of curves, the center one making a complete loop. It will be seen that there are two points on the discharge curves where the same efficiency may be obtained with different capacities and heads. For instance looking at the curve marked for 1050 r.p.m., an efficiency of 82 per cent can be obtained with a capacity of 3600 g.p.m. at 117 ft. head or a discharge of 4320 g.p.m. at a head of 105 ft. The two points are marked with "X" and "Y".

Changes in Head

To show how the same pump can be operated at different heads, take for example a pump required to deliver 3200 g.p.m. If the pump is operated at 725 r.p.m. (point "A" on the curve) an efficiency of 80 per cent could be obtained while pumping against a 49 ft. head, and a 50-hp. motor would be required. The same identical pump (point "B" on the curve) operated at 860 r.p.m. would give the required delivery (3200 g.p.m.) against a 76 ft. head, taking 75 hp., and with an efficiency of nearly 84 per cent. In a like manner (point "C" on the curve) with the pump speeded up to 1050 r.p.m. the same pump will deliver 3200 g.p.m. at 120 ft. head with an efficiency of about 79 per cent. The horsepower required would be slightly less than 125.

Similar points could be picked out for any capacity within the range of the pump, the range being limited by how low an efficiency figure the user would care to consider. In choosing a pump for a given set of conditions it will, therefore, be noted that, as there is a considerable range of high efficiency operating points, the choice may lie between several different pumps each one capable of giving good service. The characteristic curves can be changed by simply using a different type of impeller in the same casing.

There can be considerable deviation in the exact type that is finally recommended to do the job. That is why it is important to take into consideration *all* of the factors which might influence the choice. One pump will overlap into the operating field of the next in size thus making room for arguments. The manufacturer, being perhaps the best informed on his own line of pumps, can give much information to the buyer. In any case it is a good plan for the purchaser



Characteristic curves of a 10-in. centrifugal pump used to indicate how changes can be made in pumping conditions and the effects of these changes on other conditions

to insist on having a set of characteristic curves such as the ones shown here for each pump.

Capacity Changes

Due to rearrangements or changes in production it is possible that different requirements are desired for a pump. With the characteristic curves available it is easy to figure out what can be expected under the new conditions. Take for example the pump whose characteristic curves are illustrated. Originally the pump delivered 3600 g.p.m. at a 92 ft. head using 100 hp. It is desired to cut the capacity down to 2400 g.p.m. at the same head. There are two ways in which this can be accomplished. The total head may be raised (that is, the pump may be throttled anywhere in the discharge line), or the speed may be reduced. Without changing the speed the curve marked 950 r.p.m. is followed back until it crosses the 2400 g.p.m. capacity line. This point is marked 83 hp. That is, the horsepower required would be less and the head would have to be increased to 103 ft. by means of a throttle in the discharge line.

This method would require no change in the motor or other operating conditions and would require only the simple expedient of partially closing a valve. The efficiency under the new conditions would be slightly above 74 per cent in comparison with the original figure of 84 per cent. If the speed is reduced to about 900 r.p.m. the same capacity 2400 g.p.m. can be obtained with an expenditure of only 74 hp. The operating position is marked (74 hp.) on the curve sheet. The efficiency would be 76 per cent instead of 74 per cent. In this case, however, the motor would have to be changed or the speed reduced in some other way. If the pump happened to be belt driven, or driven by a gas engine, the reduction in speed could be easily accomplished and would prove a much more economical arrangement.

There is still another proposition which ought to be considered. That is, can the head be reduced in any way. If the head can be reduced the new capacity can be obtained by the expenditure of a lot less in horsepower. If the head can be reduced to 68 ft. and the speed to about 786 r.p.m., the required discharge can be obtained with about 53 hp. and the efficiency will be about 78 per cent. A curve is drawn through the 100 hp. mark and the 53 hp. mark showing how the pump would operate when changing both speed and head to obtain various reductions in capacity.

It is always desirable to reduce the speed when a change in capacity downward is desired, and conversely an increase in speed will give greater capacity. There are cases, however, where throttling can be used to advantage in reducing the capacity. For instance, consider a pump used in construction work where it is desired to vary the capacity to take care of seepage and only a constant speed drive is available. Full capacity is needed the first thing in the morning to dewater the excavation as quickly as possible, while later the flow can be adjusted to take care of the seepage. The efficiency is of little moment in such a case as long as the correct adjustment to capacity variations can be easily made.

It is impossible to predict what changing conditions may make it desirable to alter the conditions under which a pump is operating. It is not always necessary to get a new pump. With the characteristic curves available it is possible to determine what can be expected of a given pump, the speed required, the capacity, the horsepower, and the efficiency. It also shows directly whether it is at all possible to adapt the given pump to a new set of conditions, and in that way may save a costly trial. It is a good plan to have a copy of the characteristic curves for each pump handy in the files.

Combustion Control Specifications

Part III. Steam pressure, which depends on the proper balance between heat release and steam load, and furnace pressure, which depends on the proper balance of gas flow and air supply, serve as primary reference points by which automatic combustion control regulates the fuel and air supply to the furnace.

By
RICHARD H. MORRIS
Engineering Editor

FUEL SUPPLY might conceivably be handled as a single operation from the initial storage to the furnace. For simplification and convenience in considering the control, however, it is best split into two parts: from the initial storage to the bunker or intermediate storage; and from the intermediate storage to the furnace. While both are important from the standpoint of boiler operation, automatic combustion control is directly concerned only with the second and presupposes that fuel is available in such a way that its flow into the furnace can be controlled with accuracy and reliability.

The first step, may be either manually, automatically or remotely regulated independently of the combustion control but is not usually critical and the arrangement used depends primarily upon the fuel. Coal conveyors are normally motor operated and remotely controlled. They should be interlocked so that they must be operated in the proper sequence and the capacity of conveyors and bunkers is normally such that only intermittent operation is needed. From the bunkers or hoppers the coal flows by gravity to the stokers or pulverizers as needed. If the bin system of pulverized coal is used, the pulverizers are operated at constant load intermittently and independently of the rate of firing so need no connection with the combustion control which is concerned only with the feed from the pulverized coal bin.

When fuel oil is used, the arrangement is fundamentally the same but the equipment, pumps and heaters, is different and operates continuously. Oil temperature is maintained automatically by a thermostatic regulator independently of the combustion control system and arranged to control the steam flow to the heater. Variable speed pumps are usually

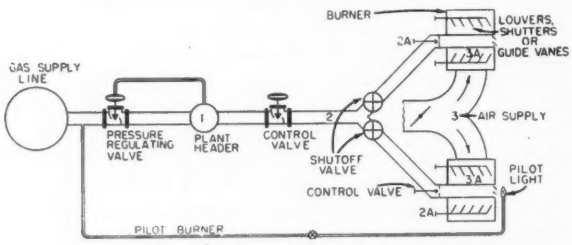


Fig. 2. Gas comes closest to being the ideal fuel and is being used as boiler fuel to an increasing extent as the network of natural gas pipelines grows. The control is relatively simple and both the gas and air are subject to quite accurate measurement. With either natural or forced draft the gas and air flows are functions of the respective pressure differentials across the burners and wind boxes

1—Gas header pressure—Held constant by self-contained automatic pressure reducing valve.
2—Gas pressure to burners—Regulated automatically by combustion control in accordance with load. Manual control valves, 2A, used to divide gas flow between individual burners as desired.
3—Air flow—Regulated automatically by combustion control, see Fig. 1. (Page 510 August issue.) Manually operated louvers 3A give control of air flow and turbulence to individual burners as needed by setting of valves 2A. On small natural draft boilers simple controls sometimes move these louvers automatically to control the air flow.

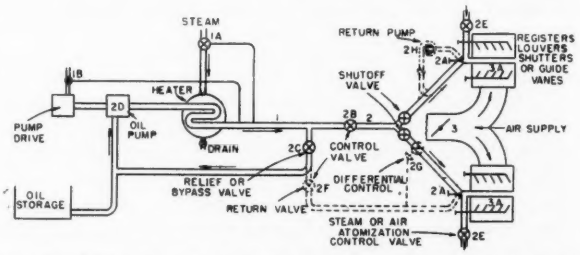


Fig. 3. Oil is not quite as simple to burn as gas for the rate of flow through the burner and complete combustion depend upon close control of the viscosity through temperature. Fuel flow is controlled by varying the pressure ahead of the burner. When steam or air is used for atomization it is usually proportioned to the oil flow by the control mechanism

1—Oil temperature—Held constant by self-contained thermostatic regulator, 1A, controlling steam flow to heater.
2—Oil Pressure at Burners—Controlled automatically through control valves 2B or 2F, depending on type of burner. Pressure ahead of pump held constant by a self contained regulator 1B varying the pump speed, or with a constant speed pump, by passing the excess oil through the spring loaded relief valve 2C. The oil temperature is held constant by a thermostatic regulator 1B controlling the steam flow to the heater. With pressure atomizing burners which use all the oil supplied to them, and with steam atomizing burners the automatic control regulates the steam pressure at the burner by valve 2B. With air or steam atomization valve 2E is controlled by the same regulator and in conjunction with control valve 2B. Pressure or mechanical atomizing burners which use only a portion of the oil supplied and return the balance have several methods of control, three of which are shown by the dotted lines. The simplest is to omit valve 2B and control the return pressure by valve 2F. This same control can be used with an independent control valve 2G which maintains a constant pressure differential across the burners. Another arrangement uses a return pump 2H which maintains a constant pressure differential across the burners. In this case valve 2B is used for control purposes. Manually operated valves 2A and air registers 3A on each burner allow adjustment of air and fuel on individual burners as with gas and pulverized coal.
3—Air flow—Regulated automatically by combustion control, see Fig. 1. (Page 510 August issue.) Vanes 3A give manual control of air flow and turbulence to individual burners.

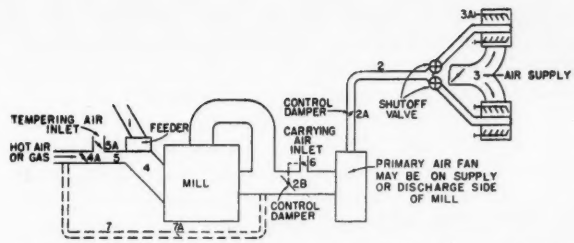


Fig. 4. Because of the equipment used the problem is more involved for pulverized fuel firing and is usually handled by a combination of manual and automatic control. This involves pressures, temperatures and flows. A large variety of mills and feeders are used, each with distinctive features. The drawing above is a composite of the features of all makes and the control points indicated are not common to all

1—Raw coal feed—Automatically controlled through speed or position of feeder by: automatic combustion control or independently by an integral controller from: mill level; pressure at outlet of mill; pressure differential across mill; mill motor input; or noise level.
2—Fuel feed—Regulated automatically by combustion control through damper 2A, damper 2B, raw coal feeder or a combination of damper and feeder.
3—Air flow—Automatically controlled, see Fig. 1. (Page 510 August issue.) Manual control of air and turbulence to each burner by vanes 3A as with gas and oil.
4—Mill inlet pressure—May be, and on some mills is always, automatically controlled but in most cases it is done manually by damper 4A.
5—Drying air temperature—May be automatically controlled by an independent controller but usually done manually by adjustment of dampers 4A and 5A. Tempering air may come from atmosphere or discharge of forced draft fan. Hot drying air or gas may come from the air heater, air cooled walls, furnace, breeching or an intermediate pass of the boiler.
6—Carrying air inlet—Sometimes used to give uniform pressure at primary air fan suction and uniform velocity through pipes. Dampers 6 may have springs or counterweights so that they open automatically to maintain a given differential, may be manually controlled, or operated automatically in conjunction with control damper 2B.
7—Hot air bypass around mill—Sometimes used with pulverizers, which normally take most of the air for combustion through the mill. Manual change of damper 7A used to take care of varying drying and combustion air requirements of different coals and also to decrease the pressure differential across the mill, especially important in increasing the air flow through air cooled walls. When hot air is not involved damper 6 gives the same regulation of air through the mill as damper 7A.

controlled by an independent regulator so as to maintain constant oil pressure in the supply system. While not universal, it is considered good practice to have the oil circulation in the supply system in excess of the combustion needs, with the excess recirculated continuously through a bypass so as to maintain a uniform temperature at all burners regardless of load and piping radiation losses.

The bypass valve is usually either of the spring loaded relief type or a valve manually operated to give the required recirculation. When the oil supply pumps are driven at constant speed, the pressure in the supply system will vary with the steam load and with the opening of the bypass valve. In this case the bypass valve is a practical method of varying the oil pressure at the burners, that is the rate of fuel feed to the furnace. As such it becomes a convenient point of application for the automatic combustion control. In this case the bypass line may be made a return line from the burners in order to minimize the length of dead end pipe to burners which are not in operation.

Gas is somewhat different in that storage is seldom provided and the gas is taken from the supply line through an automatic self contained pressure reducing valve which maintains, at all steam loads, a nearly constant gas pressure in the plant header. The absence of storage makes a standby fuel advisable with gas firing. Oil, pulverized coal and stokers are all used for this purpose, the first being the most popular because of its simplicity.

The Basic Combustion Control Trinity

Primarily the problem of automatic combustion control reduces to a detailed consideration of three things, which, for the present and without considering the fuel or order of procedure, can be taken as the automatic:

1. Supply of fuel and air to the furnace in accordance with the steam load so as to maintain the steam pressure at the desired value.
2. Maintenance of the ratio of fuel and air to the furnace so as to give the maximum practical combustion efficiency and desired excess air.
3. Control of the desired furnace pressure by a proper balance between the flow of gases of combustion from the boiler and the supply of air to the furnace.

When more than one boiler is involved, the control must do these three things for each boiler and in addition divide the total steam load between the different boilers. Obviously all three of the primary functions are inter-related and serve as a connecting link between different parts of the control which usually have no direct connection. For instance the furnace pressure regulator usually operating independently or without direct connection to the other regulators has the responsibility of keeping a balance between the air supply and gases of combustion and it may do this either by regulating the induced draft

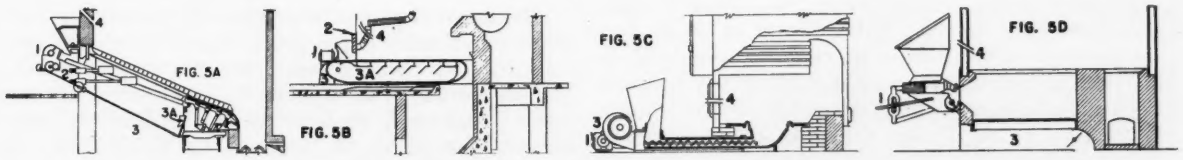


Fig. 5. Automatic stoker control is usually limited to the speed, leaving fuel bed adjustments to be handled manually by the operator. With a chain grate or underfeed stoker the rate of combustion is determined largely by the rate of air supply and only to a minor degree by the momentary rate of coal feeds that a slight delay in the latter is often permissable. This is not entirely true of the sprinkling or spreader stoker Fig. 5D, which burns a considerable portion of the fuel in suspension and a portion on the grates, thus combining the features of both pulverized coal and stokers. Here the rate of coal feed must be more closely proportioned to boiler load by means of a feeder as in the case of pulverizers. Small stokers of the single retort type, 5C, with either ram or screw feed are often built for constant speed operation with an "on and off" control of both stoker and fan from operated by pressure or temperature

1—Fuel feed—Stoker speed (or length of feeder stroke Fig. 5D) controlled automatically by combustion control.
2—Fuel bed—Shape and thickness of fuel bed controlled manually by adjustment of rams or feed gate depending on type of stoker.
3—Air flow—Regulated automatically by combustion control, see Fig. 1. (Page 510 August issue.) Pressures to individual zones manually controlled by dampers such as 3A of Fig. 5A. Forced draft chain grate stokers often have six different pressure zones.
4—Overfire air—Manually controlled; supplied by steam jets, from forced draft ducts or separate blower.

or forced draft. The balance of the control system is responsible for the first two functions, regulating the fuel and air in the proper proportion to each other and to the steam load.

While the principle by which this is accomplished depends upon the type of control system, the auxiliaries and whether the fuel is burned in suspension or in a heavy fuel bed, for all practical purposes the final results are the same, provided of course that the equipment is properly installed and adjusted. Gas, oil and pulverized coal are burned in suspension and the fuel and air must be changed simultaneously. With some arrangements this may introduce minor complications. For instance with direct fired pulverizers the lag of the fuel from the feeder through the mill to the furnace may be 10 to 30 sec. and with certain types of mills a time delay in the air supply control system is imperative for rapidly changing loads.

During the change an excess, rather than deficiency, of air is desirable because a momentary loss in efficiency is preferable to the same loss but with smoke formation. Time delays are arranged so that the air change precedes the fuel change for increasing loads and follows the fuel on decreasing loads. Beyond this there is no uniformity in practice and the fuel flow may be varied by the combustion control with either the induced draft or forced draft. Due to the high velocities of the gases through the boiler, both air and gas regulators move practically simultaneously unless a time delay is introduced by some type of variable speed drive.

In some cases both the air and fuel can be metered quite accurately and these metered indications used to maintain the desired fuel air ratio. In other cases calibrated positioned devices must be depended upon with corrections made automatically or manually by combustion indicators such as the CO_2 or steam flow-air flow meters. Details of the methods used in each case to maintain the fuel-air ratio vary with the make of the combustion control system.

Fuel to Furnace

Actual regulation of the fuel feed to the furnace by the automatic combustion control depends upon the auxiliary equipment and on the fuel. As might be expected gas is the simplest as the combustion control need move only a control valve, regulating the gas pressure at the burners. Oil is almost as simple and the pressure at the burner is commonly regulated in one of two ways, either by throttling the pressure from a constant pressure, constant temperature supply system, or, by regulating a bypass, recirculation or return oil valve. When mechanical or pressure atomization is not used the automatic control must be extended to regulate the atomizing medium, either air or steam, in parallel with the oil flow to the furnace.

When pulverized fuel firing, the direct or unit system is most widely used with the mill and primary air fan driven at constant speed. While the air flow through, the inlet pressure, and the pressure differential across, the mill have a definite bearing on performance, the combustion control problem is directly concerned with only a few of these variables. Automatic control of mill inlet air pressures and temperatures is entirely practical, but is the exception rather than the rule for manual control is usually adequate. The combustion control, therefore, is usually concerned only with the coal feed, either through the raw coal feeder, through a damper in the primary air duct, through a damper in the duct carrying the coal-air mixture from the mill or a combination of damper and raw coal feed. The control arrangement is determined quite definitely by the make of mill and feeder.

Stokers

With the sprinkler or spreader stoker a considerable proportion of the total coal is burned in suspension and the coal feed must follow the steam load very closely in parallel with the air flow. A reciprocating feeder of the variable stroke type is commonly used with the length of stroke, and consequently the fuel feed, regulated by the combustion control.

Other types of stokers carry a heavier fuel bed and the need for instantaneous parallel change of fuel and air is not so great, for the heat release is affected instantaneously by changes in the air supply, but not appreciably for some time by changes in the fuel feed. The air supply must, therefore, follow the steam load changes promptly. Although the effect of change in the rate of fuel feed on combustion is not so critical as to time, the automatic control acts immediately to change the stoker speed and bring the coal feed in agreement with their supply and steam load.

Automatic control of air and flue gas is accomplished through dampers, changing fan speeds or a combination of both, and the details depend on the auxiliaries and drives. Speed change may be through a steam throttle valve, motor controller or speed changer of some kind.

Actual movement of the dampers, valves, controllers, hydraulic or mechanical speed changers, etc., used for regulation of air, fuel or flue gas, is accomplished by power operating units which are controlled by, and may be built separate from, or integral with, the regulator proper. Three types are in general use: diaphrams operated by air or water under pressure; cylinders with pistons operated by air, oil or water under pressure, and electric motor operated units.

(To be continued)

Speaking from our own experience, I can say that every considerable expenditure of money for new and improved labor-saving machinery has had as its inevitable corollary an increase in employment in our shops. One year, when we spent $4,000,000 for machinery, our employes increased by 20,000 and our payroll by $48,000,000. Another year, when we spent $9,000,000 for machinery, our employes increased by 40,000 and our payroll by $88,000,000. And so it has gone.—Henry Ford.

Metals bob up in unexpected uses in modern industry. Monel metal for pails to reduce bacteria in poster paste and nickel to eliminate taste and odor in processing cod liver and caster oils are examples in the aseptic field.

Public Relations Start at Home

Interviews and Questionnaires Used in the Cultivation of employee good will.

IN ANY organization, the object of Public Relations activity is to promote welfare of the industry. This means good will of the organization and of customers, the latter being to a considerable extent dependent on the former, because of the altitude of employees toward the organization and their influence with the public. The logical point to start good public relations is inside the organization by cultivating employee good will and satisfaction.

One essential to improving employee good will is to know the present attitude of workers toward the policy and the methods of the management. To secure this knowledge requires tact and a procedure governed by friendly desire to get at the workers' real knowledge of and feeling about such policy and methods. Two methods are available and have been used; first, the personal interview, either casual and informal by minor or major executives, and the controlled interview in which a carefully selected list of subjects is discussed, comments by the worker being invited or specific questions asked; second, the questionnaire, in the form of a check list with multiple-choice answers to be checked, or an attitude test of statements about policies and practices with which the worker can agree or disagree, or a combination of both check list and attitude test.

Friendly interviews, in which the interest of management in workers and their welfare can be made evident are most effective, but require tact, sincerity and the wish to listen and learn. Most foremen and plant executives use this method to some extent, but often without definite plan of procedure so that no records or definite analyses of worker attitude is secured. Such interviews are of greatest value in improving morale, but results should be evaluated and reduced to a record, including suggestions which may be received as to improvement or personnel methods and working conditions.

The guided interview has the advantage of a definitely planned line of investigation and recorded answers, but the formality will put the worker on guard to avoid saying anything that he feels will react to his disadvantage, so may not get as true a picture of his attitude as an informal interview. Subjects for discussion and questions to be answered must be carefully selected to get the information desired and to relieve any apprehension that the worker may have about expressing his real thought and feeling.

Another objection to the guided interview is the time required, which makes it expensive to interview all workers, hence a representative sample list must usually be selected which may not correctly represent the whole body of workers. Since informal interviews are usually casual, in the course of daily work contacts, they are more likely to include the thought of all workers or at least to be more nearly representative of their attitude than guided interviews with a selected list.

Use of a questionnaire and attitude test to be filled out anonymously by each employee, giving only sex, length of service, kind of work, and wage classification, should invite frank answers, give recorded results that can be classified and analyzed, and prove most instructive as to workers' knowledge and thinking, and probable ways of improving morale.

Questions should deal with fundamental policies and have multiple-choice answers to be checked. Such as:

If business is bad, should the company
1. Cut working hours and share the work .....
2. Lay off some and give more work to the rest .....
3. Reduce salaries and wages .....

If business gets seriously bad, in what order should retrenchment steps be taken? Please mark 1, 2, 3, 4, 5, 6.

Reduce salaries
Cut sales promotion expense
Reduce working force
Reduce operating time
Reduce wages
Cut dividends.

These are samples only. Other questions should cover: Knowledge of and Information Desired about Company Affairs; Methods of Advancement; Wage Payment and Bonuses or Incentives; Methods of Hiring and Lay-off; Feeling about Working Conditions; Method of Handling Grievances.

In the Attitude Test the object is to ascertain the knowledge and the feeling of workers as to company policies, working conditions, fairness of wage payment and other matters affecting morale. A considerable list of statements should be included, both favorable and unfavorable to the company and its personnel practices, and workers asked to check those with which they agree.

It has been found desirable to have questionnaire and attitude test taken a department at a time, on

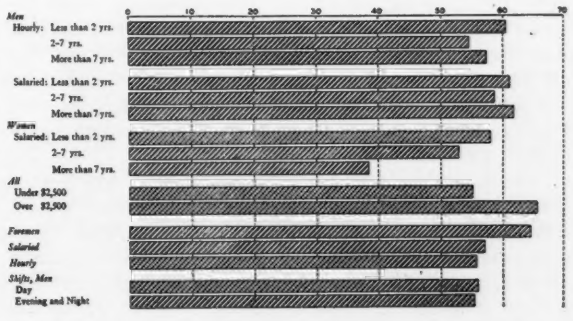


Fig. 1. Morale Classification of Classes of Employees

company time, with full protection of anonymity and no supervision of workers while answering.

Some statements which have been used are:

I am made to feel that I am really a part of the organization.

I can feel reasonably sure of holding my job as long as I do good work.

I think training in better ways of doing work should be given.

I can usually find out how I stand with my boss.

I don't get any chance to use my experience.

On the whole I think employees are treated fairly.

I think many employees would leave the organization if they could get as good jobs some other place.

I have never understood the company's personnel policy.

I cannot find out how I stand with my boss.

I think the company's policy is to pay as low wages as possible.

In framing attitude test statements, leading questions that would tend to control answers should be avoided, also direct questions as to satisfaction with present wage rate. The subjects of statements should be chosen to indicate the satisfaction or discontent of workers with conditions, policies and methods, so as to determine his mental attitude and morale.

Having the answers and check lists, they can be tabulated by sex, length of service and earnings to show the employee attitude of the classes of workers. This, in turn, should show where there is need of change in policies and methods to improve employee attitude.

Various methods may be used of evaluating results. One system is to give each statement of the attitude test a scale value, based on its importance in determining morale. For instance, on a scale value of 100 for each statement, organization feeling may be 97, job security 83, company treatment 66, experience utility 32, low pay policy 1 and others accordingly. Total of scale ratings of items checked divided by number of items checked would give the morale rating as a percentage and average of these ratings for any classification will give the rating for that classification. In a survey on 1000 workers in factory and office, the morale for men showed higher than for women, for salaried employees slightly higher than for hourly wage workers, for higher earnings workers higher than for lower earnings. (See Fig. 1.)

Study of returns showed that supervision and leadership were the most important factors affecting morale, that the feeling that pay inequalities existed was the most outstanding cause of dissatisfaction, that the wage incentive system was disliked, that work sharing was favored, that fairness of promotion policies was questioned although a large percentage of workers did not understand the company's personnel policies, and that an annual report to employees on company conditions was favored.

Information desired in the report was, amount of yearly business, amount of profits, amount paid in dividends, executives' salaries, addition to surplus, what departments are doing. (See Fig. 2.) While much of this information had been furnished, but few employees remembered profits shown for the preceding year. Misconception was widespread as to the company's policy regarding organized labor, although a quarter of the workers did not undestand what "collective bargaining" is.

Changes evidently needed were better education of employees as to finance, operation and personnel policies to improve understanding of wage, salary, hiring and lay-off administration and to give confidence in the company's fair intentions. Indications were that department managers had been "passing the buck" to higher executives in the matter of refusing pay increases, in order to keep down departmental expenses. All these were of importance as affecting employee attitude and morale and results gave a basis for future action.

In carrying out the survey, best results were obtained when the tests were given on company time

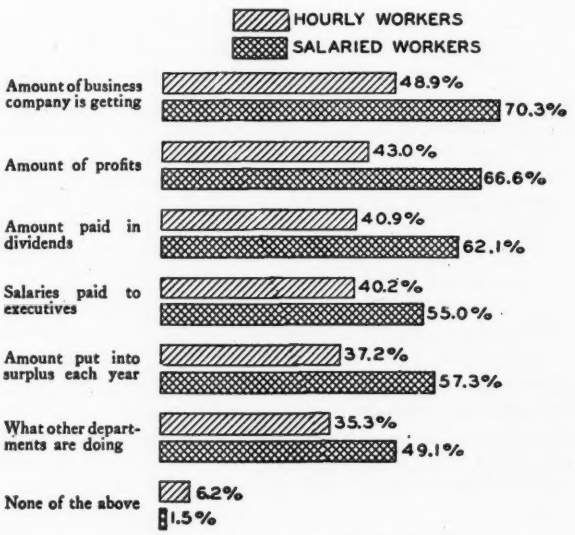


Fig. 2. Information desired by employees

by departmental groups, the purpose of the test being frankly explained, anonymity carefully preserved and no immediate superiors participating in the test. Employees dropped the filled out blanks into a ballot box and, in one case all analyses were made by an outside consulting firm, the management of the company seeing only the summaries of analyses, the grievances and the suggestions for betterment which were made by workers on a blank page of the attitude test. This system gives opportunity for each employee to express himself freely as to present methods, to offer suggestions for improvement and to get any grievance before the management with no chance for his frankness to affect his relations with major or minor executives.

Success depends, of course, on care and discrimination in framing questions and attitude statements and on tact in conducting the tests. In no case where tests were properly conducted have labor difficulties arisen as a consequence and the tests have been found helpful in promoting organization good will.

For many of the ideas of this article and for illustrative examples we are indebted to a paper by Harold B. Bergen, of McKinsey, Wellington & Co., published by National Industrial Conference Board.

Measuring Diesel Engine Performance

Oscillographs and sensitive pick-up devices make it possible to learn what actually occurs in all parts of an engine during operation

DEVELOPMENT of electric measuring technique allows new methods of investigation to be used in Diesel engine design. Investigation of the processes taking place within the engine can be made when pressure fluctuations and movements can be recorded quantitatively with reasonable accuracy. This can be done with oscillographic measuring equipment which consists of three distinct units: the electric transmitters; amplifiers; and oscillograph proper. The Siemens-type oscillograph used for the following experiments by Sulzer Brothers at Winterthur, Switzerland, can simultaneously record six operations. The manifold uses to which this apparatus may be put can best be seen from some of the measurements made in

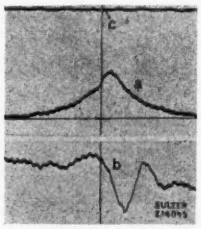


Fig. 1. Movement of the cylinder head: c indicates dead center, a is the vertical component and b the horizontal component at right angles to the cylinder axis

the Sulzer Works on single-cylinder experimental engines.

In all the oscillograms the upper dead center of the engine was marked by a deflection on the line at the top of the oscillogram (see for example d of Fig. 4), which was obtained as follows: A shallow hole of 10 mm. diam., drilled on the periphery of the shaft, moves past a stationary spool of the same diameter, the spool and the hole being opposite each other at the moment the piston is at the upper dead center. The spool is at the same time the oscillating coil for a high-frequency cathode ray tube generator.

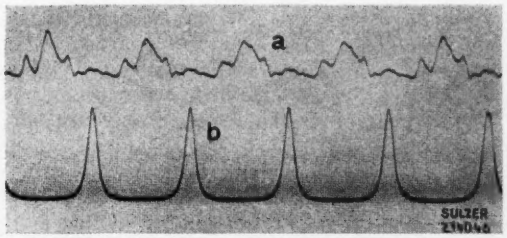
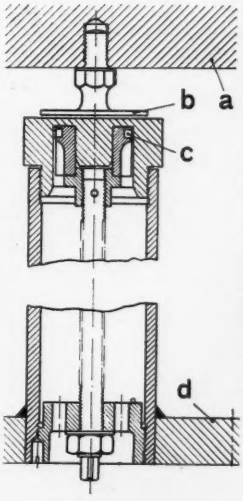


Fig. 2. Oscillogram a, shows the movement of the piston at right angles to its axis and to the axis of the crankshaft, b, is the gas pressure in the cylinder

The high-frequency amplitude is varied by changing the distance between the spool and the iron.

This high-frequency current is rectified and the rectified current recorded on the oscillograph shows the change in amplitude at the moment when the hole in the shaft fans the spool. Figure 1 shows the movement of the cylinder cover, both vertically and horizontally at right angles to the crankshaft. Figure 2 shows the lateral movements of the piston at no load, the gas pressure in the working cylinder being also shown on the same diagram.

With high-frequency coils about 30 mm. in diameter, movements can be recorded without having to fix anything to the object where movement is to be measured. The movement can be magnified up to 100 times and the oscillogram will give a record accurate to within about 2 mm. (i.e. about 0.02 mm.). The coil is preferably fixed to a micrometer screw, with which the apparatus can be calibrated so that an accurate record can be obtained independent of the amount of amplification.



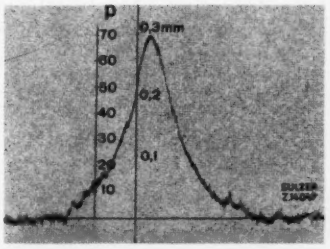


Fig. 3. Arrangement for measuring, and oscillogram of, the bending of the piston crown caused by gas pressure: a, piston crown; b, steel plate; c, high frequency spool in water tight case; d, plate fixed to piston rod. The scale p is in kilograms per sq. cm. (1 kg. per sq. cm. equals 14.22 lb. per sq. in.)

For the measurements of Fig. 1, a cast-iron weight was suspended from a crane by a spring and rope above the cover, while a high-frequency coil, firmly connected to the cover, was placed opposite to the surface of the weight. The coil in this case was not connected to a micrometer screw; as with the swinging weight, calibration could not have been made accurately in that way. To allow of accurate calibration of the records,

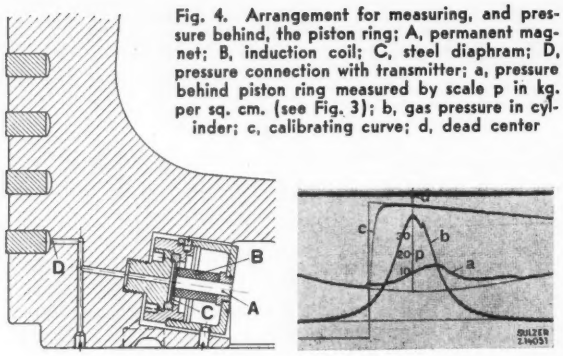


Fig. 4. Arrangement for measuring, and pressure behind, the piston ring; A, permanent magnet; B, induction coil; C, steel diaphram; D, pressure connection with transmitter; a, pressure behind piston ring measured by scale p in kg. per sq. cm. (see Fig. 3); b, gas pressure in cylinder; c, calibrating curve; d, dead center

means were provided by which the spool could suddenly be displaced by exactly 0.5 mm.

In a similar manner, the movements of the piston relative to the liner and at right angles to its axis were recorded while the engine was running. The spool was fixed on the cylinder opposite to a final line of the piston skirt and was calibrated in the manner described above.

Investigations on piston deformation during service led to measurements being made of the bending of the piston head. As shown in Fig. 3 the change of distance between the upper end of the piston rod end and the face of the piston bend was measured with the help of a high-frequency spool, which was made watertight as it had to be arranged in the cooling space. The bending caused by the working pressure gave a diagram similar to the gas pressure diagram.

Circulating cold water round the spools had no influence on the electric conditions. With hot water, on the other hand, there was a slight displacement of the zero line, but no change in sensitivity. This temperature effect was compensated by heating the calibrating micrometer spool with the warm piston cooling water.

For measuring the variation in pressure in the grooves behind the piston rings, six inductive transmitters for pressure records were fitted in the upper part of the piston, Fig. 4. The steel plate C is bent by the gas pressure. The permanent magnet A generates a magnetic flux through the casing and the steel plate, and this is modified by the air gap between the plate and the magnet. Alteration of the air gap causes a change in the magnetic flux, which generates an induced current in the spool B. Pressure variations behind the ring are shown by Fig. 4.

Quartz indicators were also used to observe the scavenging process and to examine the leakage past the piston ring. In the diagram in Fig. 5 the scale of the pressures is linear from the atmospheric line b up to a pressure of about 0.8 kg. per sq. cm. Beyond 1.5 kg. per sq. cm. the amplifier becomes inoperative.

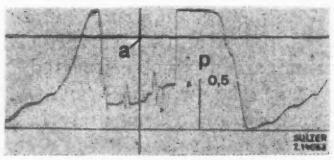


Fig. 5. Diagram of scavenging process: a, dead center; b, atmosphere line; p, calibration point at 0.5 kg. per sq. cm. pressure

Improvements in Refrigeration Compressors

SUMMARIZING the improvements of the last few years, the following have been the principal points of advancement in refrigeration compressor design.

1. Through the use of lighter and better designed reciprocating parts, and more modern and efficient types of bearings, considerably higher rotative speeds with consequently greater capacities have been attained. The limit of speed has by no means been approached. Further advancement along this line unquestionably will follow.

2. The elimination of the old stuffing box and its replacement by the modern metallic gas seal and crank case closure.

As these metallic seals have reached a high degree of perfection at this time, little advancement can be expected along these lines unless it be to hold the same degree of efficiency with a cheaper manufacturing cost.

3. There has been a decided improvement in crankshaft construction. Shafts have been shortened, main bearings given a wider margin of safety, and the need of long overhanging bearings eliminated by the use of roller bearings as outer guides and additional supports to the main bearings.

4. The use of removable bushings in all parts of the compressor, even going so far as to the use of replaceable alloy cylinder liners.

5. Use of large area, low lift, lighter valves.

6. Reduction of gas speeds due to the increase of valve area, as the later type of valve has reduced velocities down to around 4500 ft. per min. or lower. Considerable increase in speed can be obtained before valves will again have to be improved.

7. Improved lubrication wherein the more improved conventional compressors are using a double forcefeed lubricating system.

8. By means of better lubrication and improved general construction, horsepowers have been somewhat reduced, but there is still some room for improvement at this point.

9. While considerable improvement has been made in design of horizontal compressors, they have not been so numerous as in the verticals for the reason that many of the problems of vertical design are not inherent in the horizontal. The horizontal type is still a modern type.—H. C. Guild before the A.S.R.E.

THE CONTRACT for a 150-ton modern incinerator for the City of Austin, Texas, was awarded last year to the Tips Engine Works of the same city. Naturally special consideration was given to the selection of material for the grates in this installation, which have to withstand the inevitable tendency toward warpage, growth and scaling which performance of this type involves. Cr composition was modified to call for 1.50 per cent nickel and 1.00 per cent chromium, and the same material was used for the framework. The latter had to have a number of holes drilled in it, and the alloy iron machined readily.

Part IV*. Operating Cycle, Auxiliary System, and Auxiliary Equipment are the principal topics of discussion in this installment of the five-article series being published on the Delray Plant. Detailed conditions that led to the choice of the operating cycle are given, as well as an explanation of variations in auxiliary conditions that may take place with changes in load and operating schedule.

High-Pressure Extension of Detroit Edison's DELRAY PLANT

By
MAX W. BENJAMIN
Engineering Division,
The Detroit Edison Co.

WHEN central station engineers undertake the design and construction of a new power plant every effort is made to produce a plant combining satisfactory reliability from the public service point of view, high commercial efficiency, and a layout which makes "operation convenient for the operating force so that they will operate willingly and cheerfully and get the best they can out of it."† To achieve this result it is necessary to take into account the investment and thermal efficiency of the proposed design, the probable cost of fuel and labor, present and probable future load factors, system heat rate and so on. Reliable equipment must be used and the plant layout must be convenient to facilitate operation.

For many years Detroit Edison engineers have favored the regenerative cycle without reheat. Steam

*Part I was published in March, Part II in May, Part III in July, and Part V will appear in November.

† "Some Public Service Papers" by Alex Dow, p. 414.

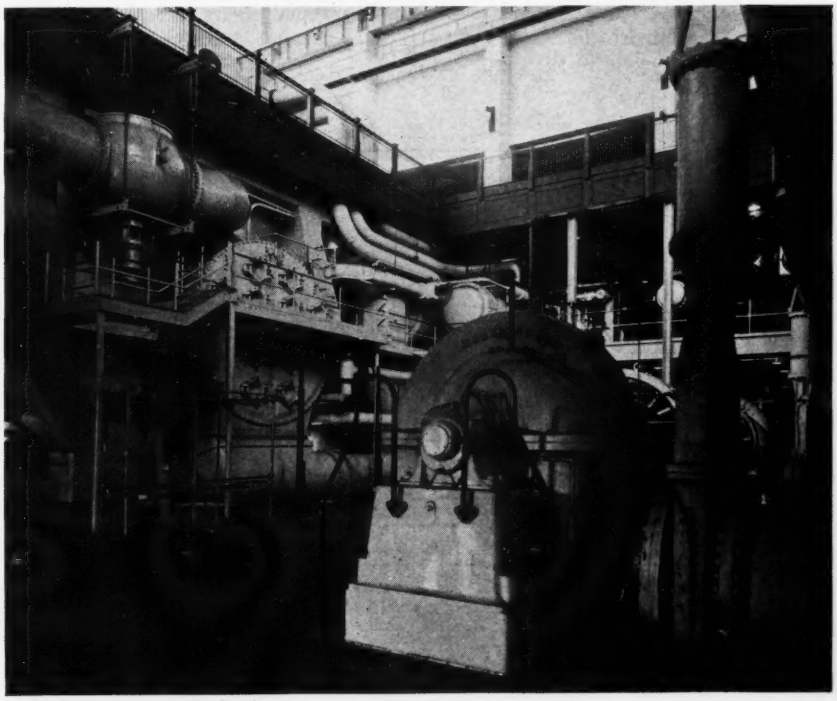


Fig. 61. General view of 75,000-kw Unit 14 from condenser room floor, showing turbine - exhaust hood, condenser, steam-extraction lines and two high-pressure feedwater heaters

is used at pressures as high as the permissible operating temperatures will allow with a conservative amount of moisture in the turbine exhaust. The now completed experimental operation of a 10,000-kw unit at 1000 F in Delray PH 3 contributed a large measure of data to the industry as a whole and pointed the way for the present widespread use of steam at temperatures of 900 to 950 F.

This fourth installment of the series discusses the operating cycle adopted for the Delray Extension, the plant auxiliary system, arrangement and drive of feedwater pumps, feedwater heaters, evaporators, and condensers and their auxiliaries.

Delray Plant

Operating Cycle

BOTH SECTIONS of Delray PH 3 operate on the simple regenerative cycle, with a 10,000-kw superposed unit operating between sections. Details of the new 75,000-kw main turbines together with a discussion of the selection of initial steam conditions of 815 psi g 900 F were given in the March issue of POWER PLANT ENGINEERING.

Main Turbo-Generators

In the older section the 50,000-kw units bleed steam to four stages of feedwater heating, producing a final feedwater temperature of 341 F at rated load. The new machines also bleed to four stages of feedwater heating, but in keeping with the higher initial pressure the final feedwater temperature has been stepped up to 388 F at rated load. Figure 62 is a flow diagram of the operating cycle in the plant extension.

The 75,000-kw turbine has a total of 17 stages. Selection of the stages for feedwater heating was determined by a study of six different bleeding arrangements. Three of these involved extraction from three stages plus an evaporator-vapor condenser, while the other three each assumed four extraction stages. Among these arrangements the calculated heat rates differed by some 50 Btu per kw-hr leading finally to the selection of the 4th, 7th, 10th, and 13th stages for extraction to four stages of heating.

As indicated in the flow diagram the leak-off steam from the high and low-tooth labyrinth shaft packing is discharged to the 7th and 13th-stage heaters while the leakage from the inner and outer glands on the control-valve stems goes to the 4th and 13th-stage heaters respectively. The leak-off line to the 13th-stage heater is fitted with a pressure gage and manually operated regulating valve by means of which the leak-off pressure is maintained at about 1 psi g to prevent inleakage of air along the turbine shaft or control-valve stems.

An evaporator operating on steam bled from the 10th stage discharges its vapor to the 13th-stage heater to provide distilled make-up for the unit. Two other pieces of heat-exchange equipment in the feedwater circuit are the air-ejector condenser, which will be discussed later, and a drain cooler.

Steam condensed in the feedwater heaters may be cascaded through successive heaters and through the drain cooler to the main condenser, but in normal operation a drain pump taking its suction from the 10th-stage heater picks up condensate from the 4th, 7th and 10th-stage heaters and pumps it into the main-condensate stream between the 10th and 7th-stage heaters ahead of the boiler-feed pump suction. Condensate from the evaporator coils and from the 13th-stage heater passes to the main condenser through the drain cooler and U-leg seal at all times. This disposition of low-pressure drains was considered necessary for the best elimination of oxygen from the boiler feedwater.

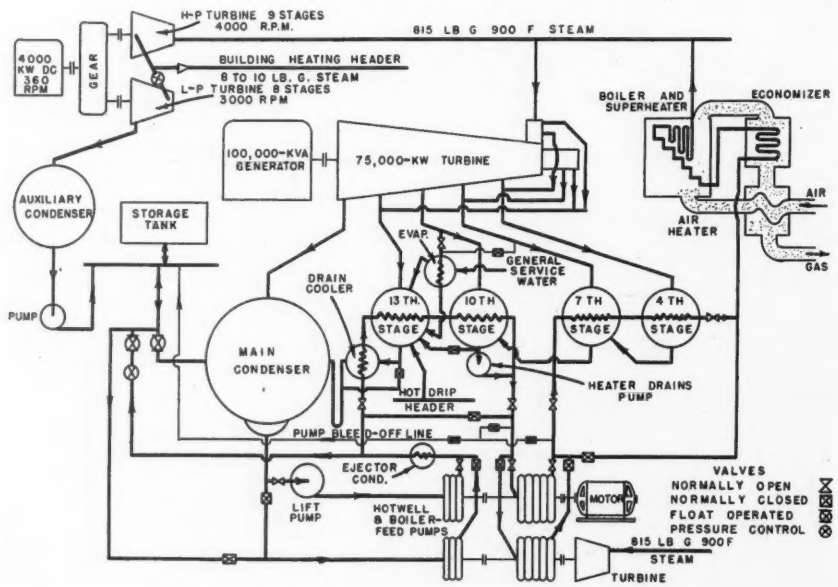


Fig. 62. Flow diagram for 75,000-kw Unit 14, showing essential connections

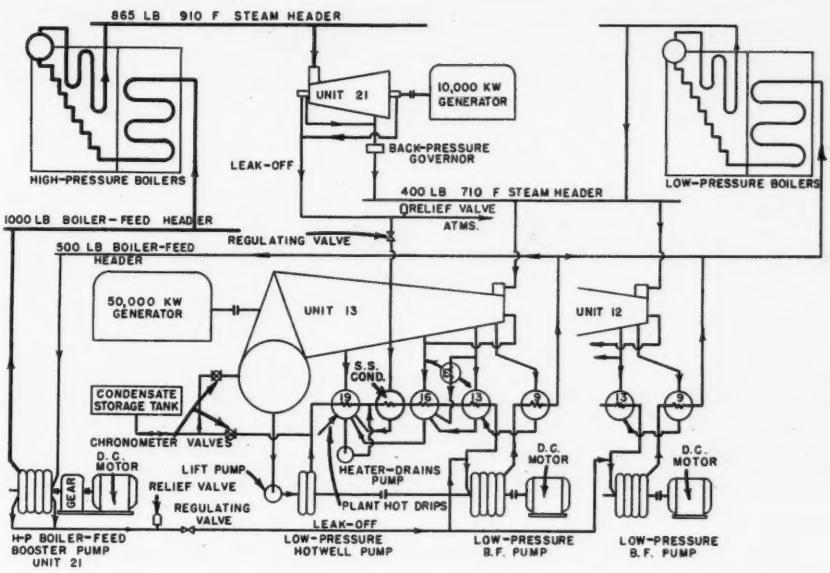


Fig. 63. Flow diagram showing connections for the 10,000-kw superposed unit between the high and low-pressure sections of the plant

At all loads above 35,000 kw the pressure in the 10th-stage heater shell will be above atmospheric and there is but little possibility for air to enter the system at that point. The 4th and 7th-stage heater shells are at still higher pressures and any non-condensible gas that might exist in those locations is eliminated by flashing and venting as the condensate cascades to the 10th-stage heater. It is believed, therefore, that oxygen-free condensate will be found at the 10th-stage heater at all loads above 35,000 kw. On the other hand, the 13th-stage heater is under vacuum at all running loads. Air might leak into the system here through joints or along valve stems, and in addition there is a relatively large quantity of oxygen and other non-condensible gas brought into the system with the raw water supplied to the evaporator. Even though the 13th-stage heater is adequately vented to the main condenser its condensate is subject to saturation with oxygen and gas which would be sent back to the boilers if the heater-drain pump were installed to take its suction from the 13th-stage heater. It is evident that from the standpoint of oxygen elimination it is desirable to pass the lowest-pressure drains to the main condenser for flashing and removal of the liberated gas by means of the steam-jet air ejectors. As an interesting circumstance of the cycle heat balance it was found that even without a drain cooler a better heat rate was possible with the drain pump on the 10th stage than on the 13th stage. Installation of the drain cooler further reduced the heat rate by 15 Btu per kw-hr. The importance of studying the different arrangements for disposing of heater drains is indicated in Table XIII.

Since both the drain cooler and the drain pump were economically justified by their own increment savings both units are installed.

Condensate collected in the main condenser is returned to the boilers by a series of three pumps. The first one, known as a lift pump, takes its suction from the condenser hotwell and discharges into the suction of the hotwell pump at about 5 psi g. At maximum flow the hotwell pump discharges at 210 psi g through the ejector condenser, the drain cooler, and the 13th and 10th-stage heaters into the suction of the boiler-feed pump. The boiler-feed pump discharges at 1092 psi g through the 7th and 4th-stage heaters to the boiler-feed header and thence to the steam-generating units.

The above described general arrangement of pumps to handle condensate and boiler feed is now almost universal in Detroit Edison plants, only the oldest section at Marysville having a different system. It is a further development of the method employed thirty years ago at old Delray Power House 1 where the boiler-feed and hotwell pump were coupled together and driven by an adjustable-speed motor. The lift pump was first used in addition to the "combination" pump at Trenton Channel, then carried over to the first section of Delray PH 3, then to the modernized Conners Creek plant and now into the Delray extension. The design of the system and the method of driving the pumps is discussed later under the heading of Feed Pumps and Their Drive.

TABLE XIII. EFFECT OF HEATER-DRAIN DISPOSAL ON TURBINE HEAT RATE

Arrangement	Saving over Cascade to Condenser, Btu per kw-hr
Cascade to condenser	0
Cascade through drain cooler	63
Drain pump on 13th stage	71
Drain pump on 10th stage, no drain cooler on 13th stage	93
Drain pump on 10th stage plus drain cooler on 13th stage	108

10,000-kw Superposed Unit

The 10,000-kw superposed unit described in the first article is the first unit of this type to be installed in the Detroit Edison system. It is fitted into the Delray plant cycle as illustrated by the flow diagram in Fig. 63.

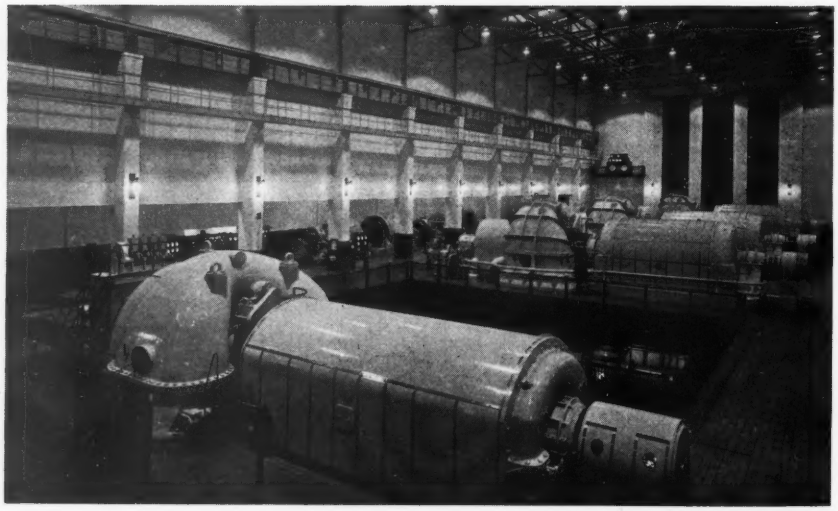


Fig. 64. General view of Delray turbine room. 75,000-kw Unit in foreground. Two of the 4000-kw d.c. house-service machines are visible in the background

Steam from the high-pressure boilers is delivered through the main-steam header to the turbine throttle. The turbine exhausts at about 410 psi g into the main-steam header of the low-pressure section, and thence finds its way to whatever low-pressure condensing machines may be in operation. In these units the steam expands to various extraction points and to the main condensers, and is ultimately delivered to the low-pressure feedwater header as boiler feedwater. With full load on the superposed turbine some 500,000 lb per hr of water is thus delivered to the low-pressure system from steam that came originally from the high-pressure boilers. In order to effect the necessary transfer of this water between the two feedwater systems, a transfer, or booster feed pump is installed to take its suction from the low-pressure feedwater header and discharge directly to the high-pressure header. Leak-off water from the shaft packing on this pump is injected into the suctions of the low-pressure main feed pumps. Leak-off steam from the turbine shaft packings and control-valve stems is condensed in a closed feedwater heater, thereby conserving its heat. This so-called "sealing-steam condenser" is installed in the condensate circuit of one of the 50,000-kw turbines, between the 16th and 19th-stage heaters. Feedwater from the 50,000-kw machine is partially heated in the sealing-steam condenser, which reduces the amount of steam extracted from the 50,000-kw turbine to the 16th-stage heater. As a result of reduced bleeding the turbine carries a given load with a sufficient saving in throttle steam to justify the sealing-steam condenser installation. On the other hand the increase in machine availability which would result from equipping a second 50,000-kw unit with a sealing-steam condenser was not considered adequate justification for such installation. A connection into the steam space of one of the main condensers also was studied but found to be too difficult and expensive to be justified by the saving in condensate alone. Consequently when the 50,000-kw main Unit 13 is out of service it will be necessary to exhaust Unit 21 shaft packing leak-off to atmosphere if the superposed turbo-generator is to operate.

The saving attributed to the sealing-steam condenser could have been equalled or bettered by condensing the leak-off steam in the 19th or 16th-stage heater shells on the 50,000-kw feedwater circuit. It is a hazardous practice, however, and one absolutely forbidden by the Company's engineering policy to admit to a main-turbine cycle steam that is not under the control of the governor on that turbine. The hazard lies, of course, in the possibility of failure of the extraction-line check valve to close in an emergency, allowing steam from the outside source to feed back into the turbine and wreck it on overspeed.

Auxiliary Electrical Systems

Throughout the plant the auxiliary equipment is driven by either alternating or direct current. Only the emergency boiler-feed pumps and emergency general-service pumps are steam driven, and on the new 75,000-kw machine a steam-jet air ejector is used.

Direct current at 240 v is supplied to all essential units whose power requirements and speed are such that direct current is suitable, and on those units that require considerable adjustment of speed. Such uses include draft fans, stoker drives, circulating-water pumps, general-service pumps, condensate-lift pumps, and boiler-feed and hotwell pumps on the 50,000-kw machines and on the 10,000-kw superposed unit.

Alternating current is used on those auxiliaries whose continuous running is not essential to plant operation, in services where sparking from d-c commutators might present a fire hazard, and in cases where horsepower and speed requirements cannot be met readily with direct current. These services include the coal handling facilities, station lighting, pumps on the transformer-oil and turbine-oil storage systems, emergency oil pumps on the 75,000-kw machines, centrifugal oil purifier, other miscellaneous pumps, elevators, air compressors, and the boiler-feed and hotwell pump on the 75,000-kw units.

Direct current for auxiliary drives is generated on either turbine-driven geared generators or motor-generator sets. In the ultimate plant there will be four turbine-driven units of 4000-kw capacity each, two 2000-kw motor generators, and one motor generator which is rated 1000-kw at 300 v. Three of the turbine-driven units operate on 375 psi 700 F steam from the

low-pressure section of the plant. They are cross-compound machines consisting of a high-pressure cylinder and a low-pressure cylinder, each driving pinions in the speed-reducing gear connected to two d-c generators mounted in tandem. Steam is extracted from the 4th stage of the high-pressure cylinder through a reducing valve to the building-heating system. The low-pressure cylinder exhausts to a high-vacuum surface condenser.

The fourth turbine-driven d-c unit, which will be installed when the second 75,000-kw main unit goes in, will operate on 815 psi 900 F steam from the plant extension. It also will be a cross-compound machine and in fact will be rebuilt from a unit almost identical with those in the low-pressure section by replacing the high-pressure cylinder of a machine no longer needed at Trenton Channel with a new high-pressure cylinder designed for the new Delray steam conditions. This unit will be equipped with a positive extraction control in place of the pressure-reducing-valve type of extraction used on the other machines to supply steam to the building-heating system. Exhaust steam will pass to the condenser formerly used with the 10,000-kw 1000 F experimental machine, while the condenser that has been serving the turbine at Trenton Channel may be moved to Conners Creek for use on the last of their 2880-kw auxiliary turbines.

All steam used by the turbine-driven direct-current house-service units is condensed, either in the building-heating system at pressures up to 10 psi g or in the auxiliary condensers at about one inch Hg absolute pressure. Disposal of the building-heating system condensate will be discussed later under "Hot-Drip System". Condensate which collects in the auxiliary condensers is pumped into condensate storage tanks by means of constant speed auxiliary hotwell pumps. Float-operated valves then pass an appropriate amount of condensate from the storage system into the main unit condenser steam space through spray pipes for the purpose of deaeration. From that point on the auxiliary condensate is mixed with the main-unit condensate and passes through the extraction feedwater heaters and into the economizers.

The direct current supply is highly reliable because operation of the turbine-driven machines is independent of all equipment in the main plant except the boilers. These turbo-generators are equipped with their own condensers, circulating pumps, hotwell pumps and other auxiliaries, and actually constitute a separate direct-current generating plant within the main plant, housed in an auxiliary bay of the turbine room between the boiler room and main turbine floor. The auxiliary bay and some of the house-service turbines may be seen in the background of Fig. 64.

The 2000-kw motor-generators, one of which is now installed, also are located in the auxiliary bay. They provide running reserve on the d-c system and are of value in balancing the load for good steam economy in the turbine-driven sets. In the matter of independence, however, they do not measure up to the standards set for the turbine-driven units since their motive power

TABLE XIV. OUTLINE OF ELECTRIC AUXILIARY SYSTEM DELRAY PH 3

Current	Direct current	Alternating current
Voltage	240	4800; 240; 120; 28
Motors	Practically all shunt wound. A few have cumulative compound windings.	All coal handling motors are totally enclosed, fan ventilated wound rotor motors. The main air compressors and 75,000-kw feed pumps are driven by 4800 v. motors; other motors are 220 v.
Lighting		120 v; 28 v
Service	Essential Aux. with exception of boiler-feed and hotwell pumps on 75,000-kw units.	Non-Essential Aux. and boiler-feed and hotwell pumps on 75,000-kw units.
Switches and Circuit Breakers	Air circuit breakers on d-c control equipment. Enclosed fused knife switches between bus and controllers.	4800 v—all oil circuit breakers. 240 v—oil circuit breakers on coal handling; enclosed air circuit breakers for general distribution.
Source of Energy Supply	4000-kw d-c House Generators driven through reducing gears by steam turbines, and 2000-kw motor-generators.	Service connection to main electrical system through two nearby substations.
Emergency Supply Provisions	Always have sufficient machines on line to carry the load if one should drop its load. Two 2000 kw M.G. sets and one 1000 kw M.G. set for running reserve and standby. M.G. sets driven by 4800 v., a-c.	Connections of two substations is considered sufficient emergency supply provision. (Waterman and Delray Substations)
Boiler-Feed Pump Drive	Hotwell and boiler-feed pumps for 50,000-kw units mounted on same shaft and driven by adjustable speed d-c motor. Hotwell pump takes its suction directly from discharge of a constant speed "Lift" pump whose function is to take water from condenser hotwell and discharge it at about 2½ psi g. Boiler-feed booster pump for 10,000-kw superposed unit driven by adjustable speed d-c motor and speed-increasing gear.	Hotwell and boiler-feed pumps for 75,000-kw units mounted on same shaft and driven by adjustable speed, 4800 v, a-c slip-ring motor. Hotwell pump takes its suction directly from discharge of a constant speed d-c driven "Lift" pump whose function is to take water from condenser hotwell and discharge it at about 7 psi g.
Emergency Boiler-Feed Pump Drive	Hotwell and boiler-feed pumps mounted on same shaft and driven by direct-connected steam turbine. Turbine has one wheel and can be started just as readily as an electric motor. Hotwell pump takes its suction directly from condenser hotwell. No emergency pump installed for superposed unit.	
General-Service Pump Drives	Regular pumps driven by adjustable speed d-c motors. Emergency pumps driven by direct-connected quick-starting steam turbines.	

comes from busses and transformers in Waterman and Delray substations, through cables to an a-c bus in the power plant.

Alternating current auxiliaries operate at different voltages from 4800 on the air compressor motors and 75,000-kw feed pump motors down to 28 v on service outlets, depending on the conditions of use. As indicated above, these services are supplied from a-c busses, energized from the two substations remote from the power house but on the plant site. Table XIV gives an outline of both the d-c and a-c systems.

Condensate-Storage System

Installed in the plant is a condensate-storage system which serves both sections of the plant in three different ways. It serves as a reservoir for evaporated make-up and for a reserve supply of condensate which could be fed to the boilers in case of blowing of the safety valves as a result of failure of one or more main units. The system also serves as a surge chamber to receive water at times of increasing plant load and to supply water to the feedwater system when the plant load decreases. This surge capacity is required to compensate for the change in volume of steam bubbles in the boiler at different rates of evaporation. The third function of the system is to receive condensate from the house-service turbines and provide for the transfer of that condensate to the main unit boiler-feed systems.

The condensate-storage system consists of four rectangular steel tanks of 47,000 gal capacity each, connected to a 12-in. storage header from which there is a 6-in. branch to the condenser and pumps of each main unit. The hotwell pumps of the auxiliary turbines discharge directly into the storage header. Float-operated chronometer valves, indicated in the flow diagram, Fig. 62, control the flow of condensate between the main units and the storage tanks, there being two separate valves for each generating set. Operation of the chronometer valve is as follows:

During periods of increasing load on the station the rate of firing in the boiler furnaces is stepped up and an increasing part of the boiler volume is occupied by steam bubbles. Because of this displacement of solid water, the boiler-water level is temporarily satisfied with a reduced amount of feedwater, and the boiler-water level regulator prevents the feed pumps from pumping water out of the condenser as fast as the condensate forms. Consequently the water level rises in the condenser hotwell. A float located in a specially provided chamber, which is connected top and bottom through pipes of liberal size to the space above and below the limits of water level in the condenser hotwell, opens the high-level chronometer valve and allows water to flow from the hotwell pump discharge to the condensate-storage tanks. When the plant load is decreasing the steam bubbles in the boiler diminish in volume, temporarily requiring an excess of feedwater to maintain the proper boiler-water level. As a result the water level in the condenser hotwell falls, opening the low-level chronometer valve to admit water from storage into the condenser steam space through the spray pipe. Under steady load conditions there is some flow of water from storage through the low-level valve to introduce condensate from the auxiliary machines into the main condensate circuit. Were it not for the auxiliary condensate both chronometer valves would be closed under steady load operation. With the above described automatic means for surge-water control, the operator merely has to adjust the speed of the feedwater pump to maintain sufficient pressure to feed the boiler.

Fundamentally the same design of condensate-storage system is used at Trenton Channel, Conners Creek, and Delray. Some interesting refinements have been made, however, in the chronometer valve and float box design since the first ones were installed at Trenton Channel. In the older arrangements a heavy cast-iron box housed a ball float which was connected by an external linkage to the chronometer valve. In the newer design, illustrated in Fig. 65, the float box is built up of welded steel plate and is so arranged that the valve body is bolted to it. The float then acts directly on the valve without any external levers and therefore without stuffing boxes that might either bind or permit air to leak into the system. The valve

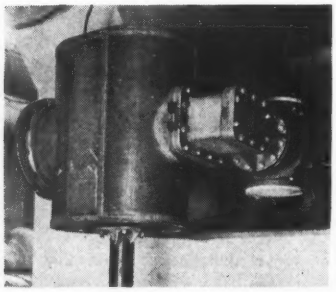


Fig. 65. Welded steel float chamber and improved chronometer valve for controlling flow of condensate to and from the storage tanks—Above

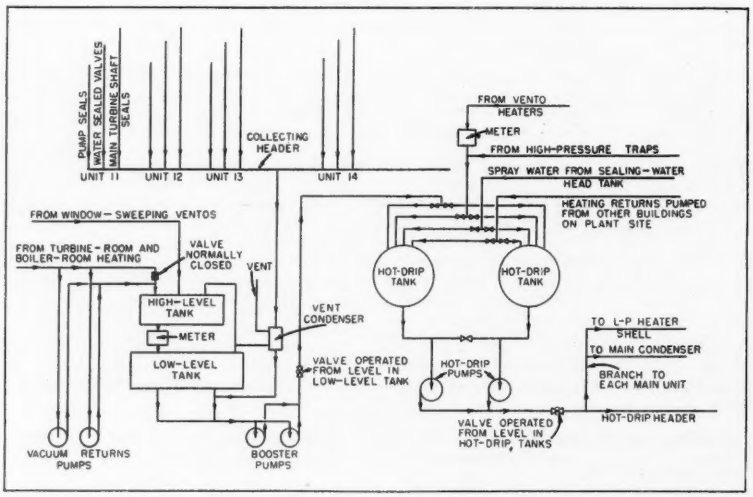


Fig. 66. Basic diagram of the Delray hot-drip disposal system. Complete valving is not shown, and details have been omitted—Right

itself is of the ported-cylinder type which opens and closes by rotating about the axis of the valve stem. Valves designed ten years ago had a secondary adjustment that consisted in moving the cylinder along the length of the stem to increase or decrease the length of the ports. This adjustment, when once made, was left as set. By designing the ports to suit the individual case it is no longer necessary to provide for the lengthwise adjustment, which, of course, contributes to the improved design.

Another feature of the condensate system which requires some mention is a spring-loaded pressure-control valve ahead of the high-level chronometer valve. Because the static elevation of the storage tanks above the hotwell and boiler-feed pump is only 13 ft there would be some danger of losing pressure between the hotwell pump and boiler-feed pump if the high-level valve were to open suddenly. In such an event the boiler-feed pump would become vapor bound with flash steam, causing an interruption in the boiler feedwater supply. The spring-loaded pressure-control valve prevents such a failure by holding the hotwell-pump discharge pressure up to a pre-set minimum value, well above the flashing point.

By-passes are provided around both chronometer valves to permit repairs without shutting down the main unit, or to provide extra capacity in unusual operation.

Hot-Drip System

In the operation of a large power plant there are many miscellaneous items of condensate that must be disposed of in one way or another. An arrangement of pumps, pipes, and tanks, known as a hot-drip system and diagrammed in Fig. 66 is installed at Delray to collect and return to the boilers all the items of condensate that can be collected without contamination by oil, dirt, or other foreign matter. The sources of condensate served by this system include the following:

1. Building-heating system
2. High-pressure trap discharges, (Drip piping was discussed in the installment on piping)
3. Water supply to
   - (a) Main-turbine shafts seals
   - (b) Auxiliary-turbine shaft seals
   - (c) Boiler-feed-pump shaft seals
   - (d) Hotwell-pump packing glands
   - (e) Heater-drain-pump packing glands
   - (f) Main-condenser relief valve seals
   - (g) Auxiliary-condenser relief valve seals
   - (h) Relief valve seals on low-pressure feedwater heaters
   - (i) Atmospheric relief valve seals on auxiliary feed pump turbine exhaust to main condenser

Building heating is accomplished with steam extracted from the house-service turbines at 10 psi g. supplemented by steam taken from the boiler drums through reducing valves whenever necessary. Disposition of the condensate from the building-heating steam depends upon the pressure and/or elevation at which the returns leave the heating apparatus. For example, the turbine-room and boiler-room heating systems may be under vacuum. Their returns flow by gravity to vacuum returns pumps located in a pit below the basement floor at the north end of the plant. The vacuum pumps lift these returns into a high-level receiving tank from which they flow by gravity through meters into a low-level tank. Booster pumps discharge the returns from the low-level tank into the hot-drip tanks located just above the headers in the west header gallery at an elevation about 15 ft above the basement floor. Returns from a system of window-sweeping ventos flow by reason of their pressure and elevation directly into the high-level tank in the heating-returns pit where they join the condensate discharged from the vacuum returns pumps. Returns from roof-sweeping ventos and from radiators high up in the plant, and returns pumped to the plant from other buildings on the Delray site flow through a meter and into the hot-drip tanks. Thus all of the building-heating steam is metered on its way to the hot-drip tanks.

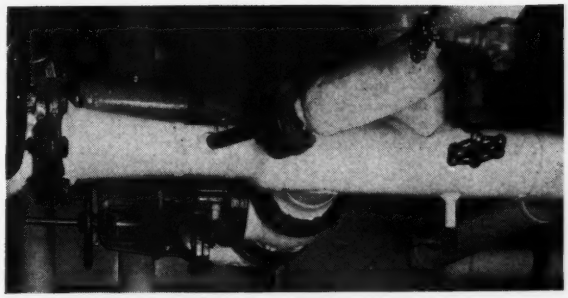


Fig. 67. Diffusion nozzle used for mixing hot-drips with condensate flowing from the storage tanks to the main condenser

Condensate discharged from the high-pressure steam traps passes directly to the hot-drip tanks without metering.

Return water from the seals enumerated above is collected in a header that lies in a trench in the basement floor and passes, without metering, to the low-level tank in the heating return pit. Ultimately it reaches the hot-drip tanks along with the various heating returns.

The temperature of the mixture in the hot-drip tanks varies with conditions. However, if there is a high ratio of trap discharges to return water from seals, it is necessary to introduce a certain amount of cold condensate into the tanks to temper the mixture to a condition suitable for pumping. This cooling water, which is taken from the same source as the water supply to the seals, is introduced into the hot-drip tanks through spray heads as a means of condensing any flash steam and cooling the condensate. The final temperature of the mixture is about 170 to 180 F.

The last stage in the hot-drip journey is the return from the hot-drip tanks to the condensate systems of the main units. This may be accomplished in either of two ways. First of all, hot-drip pumps discharge the water from the tanks into a header which runs length-

wise of the plant and feeds branches to each main unit. From the branch the hot-drips may pass either

(1) to the steam space of the lowest-pressure feedwater heater or

(2) to the throat of a mixing nozzle, shown in Fig. 67, in the condensate line from the storage tank to the low-level chronometer valve supplying make-up to the main condenser.

Hot-drips introduced into the heater shells on the 50,000-kw units may carry with them some oxygen that could dissolve in the heater condensate and be returned to the 400 psi boilers. On the 75,000-kw units the drains from the lowest-pressure heater pass through a drain cooler and into the main condenser, so that deaeration of the hot-drips in the 75's is automatic.

Deaeration is assured in all cases if the hot-drips are introduced into the main condensers along with the make-up from storage. There also is another definite advantage from this method of disposal, especially in the summer time. Because of the relatively light load at which the turbine-driven d-c machines usually operate, their condensate invariably is cooler in summer than that from the main units. Consequently the temperature of the water in the condensate-storage tanks is quite likely to be somewhat below the saturation temperature in the main condensers. Under this condition there can be no flashing when the condensate make-up enters the condenser steam space and deaeration is effected only by mechanical spraying. Introduction of hot-drips into the make-up stream produces a warm mixture, causing some flashing and effecting a more complete liberation of dissolved oxygen.

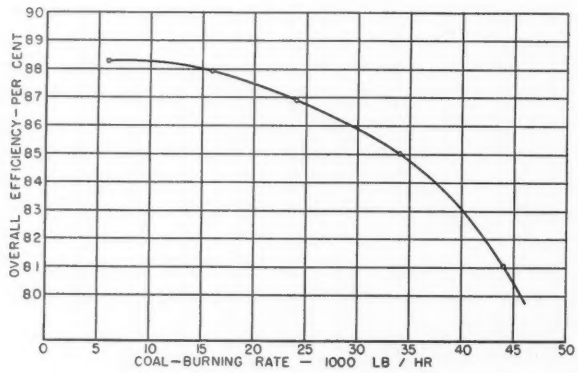


Fig. 68. Curve showing overall efficiency for which the high-pressure steam-generating equipment is designed

Sealing-Water System

Sealing water for the various rotating shaft packings and glands and for water-sealed valves is supplied from a central head tank located in the auxiliary bay fan room, at an elevation of some 40 ft above the main turbine shaft. This tank, which has a capacity of 3750 gal, feeds a header in the basement. Branches to the individual units are connected to the header at convenient points along its length. Cold condensate is supplied to the head tank from the discharges of the several hotwell pumps. A 2½-in. line from each hotwell pump connects into a 4-in. supply header in the basement. From the header a single riser feeds the head tank through a float-operated valve. To provide against a possible failure of the supply of condensate to the head tank, an emergency connection is made into the general-service water system in the plant. A float-operated valve in the general-service line is set to open at a pre-determined low-water level in the tank. Normally the general-service valve is closed, and because no leakage of general-service water into the condensate would be tolerated, a tell-tale is provided between the float-operated valve and the head tank.

It sometimes is desirable, especially during tests, to seal a machine with its own condensate rather than from a pooled source. Connections are provided so this can be done, thereby eliminating the need for corrections which would be required in testing if water from an external source were used.

Delray Plant

Boiler-Room Heat Balance

THE SECOND installment of this article, which appeared in Power Plant Engineering for May, 1939, covered the design and construction features of the steam generating equipment in some detail and summarized the performance for which the equipment is designed. The design performance will be elaborated somewhat in the following paragraphs.

All of the new boilers are designed for operation with coal on underfeed stokers, but three of them are equipped also with gas burners for the simultaneous firing of blast-furnace gas and coal.

Air for combustion enters the air heaters at 100 F and is delivered to the gas burners and stoker plenum chamber at temperatures ranging from 290 F to 357 F depending upon the rate of firing. Furnace temperature varies from 1540 F to 2400 F. Preliminary tests indicate that up to 36 to 38 per cent of the total heat released in the furnace is absorbed by the water-cooled furnace walls.

The hot gas then passes over the three rows of boiler tubes ahead of the superheater after which the gas stream is divided, a part flowing over the superheater tubes and the remainder through the superheater by-pass, in whatever ratios are necessary to maintain a constant superheated-steam temperature throughout the normal range of load. Beyond the superheater are five more rows of boiler tubes which reduce the gas temperature to average values of from 690 F to 1105 F. These averages are made up of gas at temperatures as high as 1560 F leaving the by-pass section and cooler gas from the superheater section.

The economizer is designed for a water inlet temperature of 375 F at all loads since the boiler rating and turbine loading may vary somewhat independently. Actually the feed temperature may range from 250 F to 390 F, depending on the turbine load. Operation of the superposed machine, which was decided upon after the boiler design was finished, may reduce the average economizer feed temperature below the design figure of 375 F since the steam used in the superposed unit will be condensed in the low-pressure section of the plant. As mentioned in the beginning of this installment, the feedwater temperature in the low-pressure section at rated turbine load is 341 F, and water from the low-pressure feedwater system will be pumped directly into the high-pressure feed system in amounts equal to the steam used by the superposed machine. Since the superheater by-pass partitions extend through the economizer there are three definite gas paths through it with different gas temperatures in the middle section than will be found in the end sections. The maximum gas temperature leaving the by-pass section of the economizer is expected to be 660 F while the average gas temperature leaving the economizer varies with rating from 410 F to 530 F.

The air heater design calls for cooling the products of combustion to final temperatures ranging from 240 F to 337 F, depending on the rating. If the temperature reduction in the gas circuit is compared with the temperature rise in the air circuit it appears that the air heater is designed for ratios of gas to air from 1.12 at light loads up to 1.35 at maximum rating. Actually the gas to air ratio varies from 1.21 to 1.28 depending on the variations in specific heats and the amount of air infiltration into the gas circuit through ash pit, furnace, and economizer casing.

Design performance of the steam generating equipment under the above described conditions results in overall steam generation efficiencies shown in Fig. 68.

Delray Plant

Feed Pumps and Their Drives

A CONSTANT supply of water at boiler-feed pressure is essential to the safe and successful operation of any boiler plant. While various arrangements for accomplishing the desired result are favored by different designers, the type of system used in the Delray extension has given over fifteen years of satisfactory operation in the different Detroit Edison plants. The arrangement is indicated in Fig. 62 and has been touched upon briefly in the discussion of the plant heat cycle. Motor-driven pumps are used in normal operation, while turbine-driven pumps are installed as standby equipment.

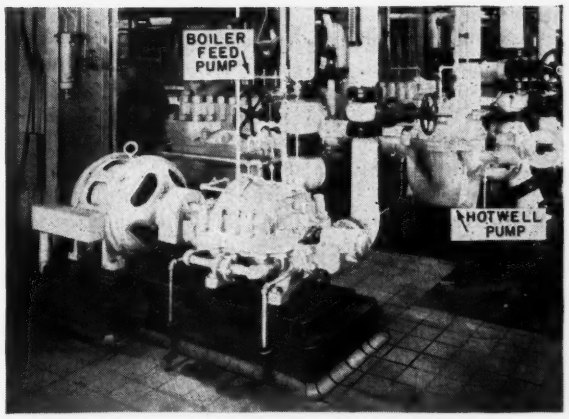


Fig. 69. Motor-driven boiler-feed and hotwell pump for 75,000-kw turbine. The constant-speed heater drain pump is in the foreground

Pumps for 75,000-kw Units

Three pumps in series constitute the main pumping system in the motor-driven units. The first is a relatively slow-speed low-head "lift pump" which lifts water out of the condenser hotwell and discharges at a few psi g into the suction of the "hotwell pump." The purpose of the lift pump is, through low-speed low-head operation, to avoid cavitation with its noise and other possible effects. This pump is driven by a d-c motor at a constant speed of 600 rpm.

Next in the series is the hotwell pump which receives water from the lift pump and increases its pressure to some 200 psi g. From this pump the condensate flows through the 13th and 10th-stage heaters into the suction of the boiler-feed pump. In this part of the circuit the water is heated to about 255 F at maximum load, and loses about 41 psi pressure in friction through the two heaters, drain cooler, ejector condenser, and the interconnecting piping. Heater drains accumulated in the hotwell of the 10th-stage heater are pumped into the condensate circuit at the suction of the boiler-feed pump.

The boiler-feed pump, which is on the same shaft as the hotwell pump, increases the pressure of the hot water to a final value of 1092 psi g at maximum load, and delivers it through the 7th and 4th-stage heaters into the boiler-feed system. Another 135 degrees of temperature are picked up as the water flows through the last two heaters, resulting in a final feedwater temperature just under 390 F at maximum load. The

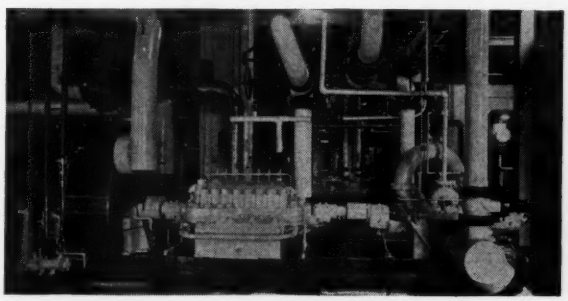


Fig. 70. Turbine-driven emergency boiler-feed and hotwell pump for 75,000-kw turbine

accompanying pressure loss in these two heaters and inter-connecting piping is about 30 psi.

The hotwell and boiler-feed pumps, shown in Fig. 69, are coupled in tandem and driven by an adjustable speed a-c slip-ring motor having a top speed of 1780 rpm. An emergency pumping unit, shown in Fig. 70, driven by a steam turbine operating on 815 psi g 900 F steam consists of a boiler-feed pump identical with the motor-driven unit, coupled to a hotwell pump which is designed to take its suction directly from the condenser hotwell if necessary, or directly from the condensate storage system. The turbine is a single-pressure-stage machine designed for ruggedness and quick starting. Because the stand-by unit operates only during emergencies and periodic tests cavitation in the hotwell pump is not considered important enough to complicate the system with a stand-by lift pump. Some other arrangements of feed pumps were considered before the system used was decided upon. These will be discussed shortly.

In the previous installment, on piping, mention was made of the shut-off pressure and rated discharge pressure of the pump in comparison with the normal discharge pressure as they affect the piping design. Since it may be of interest to some readers, a discussion of the considerations involved in establishing the ratings of the different pumping units is given below.

One important function of a boiler-feed pump is to supply water to a boiler under conditions in which the boiler safety valves are blowing wide open. Such circumstances arise when a large block of load is dropped suddenly due to tripping of one or more main turbo-generator stop valves or machine switches. In the case of stoker-fired boilers some little time elapses before the coal-burning rate can be materially reduced. In such an emergency the boiler-drum pressure rises until the safety valves open, and the rate of evaporation remains essentially constant until the fans are stopped. Under these conditions the boiler-feed pumps should continue to pump at the same rate as immediately before the emergency, but at an increase in pressure corresponding to the increase in boiler-drum pressure.

Due to the water-storage capacity of the boiler coupled with the desire to maintain a relatively low water level so as not to flood the superheater in case normal conditions are restored promptly it might be argued that the pump need not deliver its full rated capacity at the increased pressure. This might be acceptable practice for a motor-driven pump especially if the emergency pump is turbine-driven and is capable of being over-speeded somewhat. On the other hand, if the motor-driven pump is arranged for adjustable speed there is not much to be gained by building the pump for any condition less than full capacity at emergency pressure.

In the case of the 75,000-kw Delray unit it is possible to obtain full capacity in the motor-driven unit and since a slip-ring motor is used for the drive it was decided to design the motor-driven and turbine-driven units for the same rating conditions. This rating point at the discharge of the boiler-feed pump is 684,600 lb per hr of water at 260 F at a gage pressure of 1186 psi. The pressure is made up as follows:

Setting of first saturated safety valve	950
6 per cent over-pressure	57
Economizer friction drop	12.5
Drop through regulating valves	47
Calculated pipe friction	39.1
Heater friction (4th and 7th stages)	28.2
Static head to boiler nozzle	36
Allowance	16.2
Total at pump discharge	1186.0 psi

The pressure at the suction of the boiler-feed pump will be equal to the more or less arbitrarily established hotwell pump discharge pressure minus the friction loss through the condensate piping and various feedwater heaters. This friction loss is calculated as follows:

Piping	9.7
Ejector condenser	5.6
Drain cooler	10.0 (estimated)
13th-stage heater	8.7
10th-stage heater	6.8
Total	40.8 = say 41 psi

To allow for some surge to storage, the capacity of the hotwell pump is specified as 785,000 lb per hr of water at temperatures from 58 F to 102 F. In order to provide an ample margin of pressure above flashing pressure in the boiler-feed pump suction, the hotwell-pump discharge pressure is specified as 200 psi g minimum and at the same time it is stipulated that the hotwell pump pressure shall not exceed 300 psi g at shut-off. The rated discharge pressure actually selected is 210 psi g for the motor-driven unit operating in series with the lift pump and 210 psi g for the turbine-driven unit without the lift pump. The suction pressure on the boiler-feed pump under rated conditions therefore is 210 — 41 = 169 psi g.

The suction pressure on the motor-driven hotwell pump is taken arbitrarily at 5 psi g, two pounds less than the rated discharge pressure of 7 psi g for the lift-pump. The turbine-driven hotwell pump will take its suction directly from the condenser at from 2 psi abs to 3 psi abs depending on the condenser pressure and water level in the condenser hotwell. These latter suction conditions apply also to the motor-driven lift pump. The rated capacity of the lift pump is 785,000 lb per hr at 58 F to 102 F.

The heater-drains pump shown in the foreground of Fig. 69, which discharges condensate from the 10th-stage heater hotwell into the suction of the boiler-feed pump, is designed for 143,500 lb of water per hr from a suction pressure of 7.9 to 15.8 psi abs to a discharge pressure of 226.8 psi abs. The variation in suction pressure is due to the elevation of the heater above the pump, which permits considerable change in water level in the suction pipe. This variation is utilized to obtain automatic regulation of the pump, which is driven by an induction motor at 1750 rpm. At light loads the water in the suction pipe is pulled down to a low level and at heavier loads it carries at higher levels. This is the first constant-speed heater-drain pump in the Company's experience. Older installations are all driven by adjustable-speed motors.

Boiler-Feed Pump Drive

In keeping with the policy of driving all essential auxiliaries with direct current it was for many years

standard practice to use adjustable-speed d-c motors on boiler-feed pumps. Motors for the 50,000-kw pumps at Trenton Channel and in the first section of Delray PH 3 are rated at 700 hp, and operate at 1000 to 1200 rpm on 240 v direct current. The boilers fed by these pumps generate steam at just over 400 psi g.

When 600 psi g pressure at the turbine throttle was adopted for Conners Creek it became necessary to review the question of pump drive. Because of possible commutation trouble in motors of the required horsepower at speeds over 1200 rpm it was considered necessary to limit the speed of d-c motors to that value. On the other hand this meant either an undesirable increase in the number of stages in the pump or the installation of a speed-increasing gear between the pump and motor. Another arrangement considered the use of a "primary" and "secondary" boiler-feed pump in addition to the lift pump and hotwell pump. This design split the long boiler-feed pump into two units each having an acceptable bearing span. Speed adjustment would have been provided on only one of the feed-pump elements. All these arrangements involved extra room which was not available, and extra expense which was not warranted. Steam-turbine drive also was considered, but abandoned when the expense of an extra feedwater heater-condenser was considered and theoretical conditions of instability were discovered. Slip-ring a-c motors finally were selected for driving the Conners Creek pumps as being the best compromise between the necessary operating speed of the pump, investment cost, space limitations, and speed adjustment. It has proved to be an entirely satisfactory drive.

With a background of experience at Conners Creek it was assumed that the same arrangement would be used in the Delray extension. However, increasing the throttle steam pressure to 815 psi g necessitated a corresponding increase in the rated pump pressure and some of the pump manufacturers required a speed in excess of 1770 rpm to meet the specification. Upon investigation it was found that 1500 hp slip-ring motors were not available at 3550 rpm, the next higher 60 cycle full-load speed, and the question of drive was again opened.

Constant speed induction motors could be used, of course, but these involved a throttling loss at all reduced loads. Furthermore, the maximum pressure normally encountered at the pump discharge would be nearly 100 psi less than the rated pressure. This loss of 100 psi represents about 150 hp, which would be a serious waste if it had to be tolerated whenever the pump was in service. To avoid this loss a scheme was studied in which the pump would be divided into two units, each driven by a constant speed motor. The main pump would be designed to generate the head needed in normal operation while the other pump would operate in series with it to produce the total head needed in emergencies. The second, or "by-pass booster," pump normally would be under pressure with the feedwater flowing around it through an open by-pass. In emergencies it would be necessary only to close the motor circuit on the by-pass pump. The by-pass itself would be check-valved to prevent recirculation with the by-pass pump running. Not all pump manufacturers were limited to the high speed, however, and when all the factors had been evaluated it appeared desirable to select a pump for which an adjustable-speed slip-ring motor could be obtained. The system and pump drive in the Delray extension are similar, therefore, to the corresponding equipment at Conners Creek, the heads, capacities and motor horsepower being suited to the new requirements.

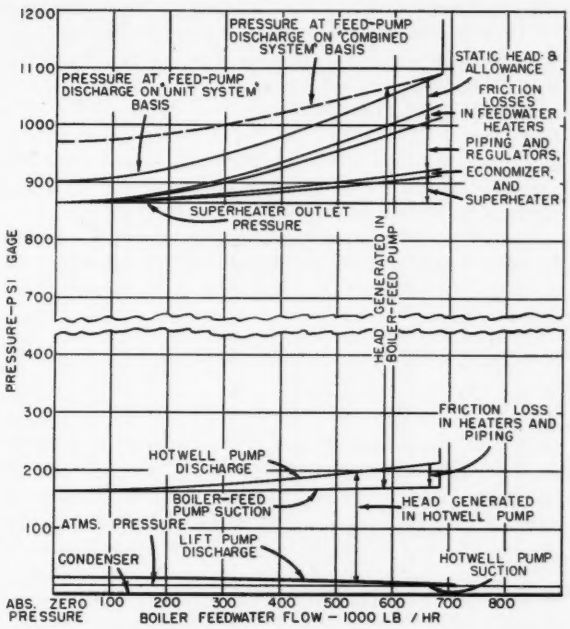

PRESSURE AT FEED-PUMP DISCHARGE ON COMBINED SYSTEM BASIS
STATIC HEAD & ALLOWANCE
PRESSURE AT FEED-PUMP DISCHARGE ON UNIT SYSTEM BASIS
FRICTION LOSSES IN FEEDWATER HEATERS
PIPING AND REGULATORS, ECONOMIZER, AND SUPERHEATER
SUPERHEATER OUTLET PRESSURE
HEAD GENERATED IN BOILER-FEED PUMP
PRESSURE—PSI GAGE
FRICTION LOSS IN HEATERS AND PIPING
HOTWELL PUMP DISCHARGE
BOILER-FEED PUMP SUCTION
HEAD GENERATED IN HOTWELL PUMP
ATMS. PRESSURE
LIFT PUMP DISCHARGE
CONDENSER
HOTWELL PUMP SUCTION
ABS. ZERO PRESSURE
BOILER FEEDWATER FLOW — 1000 LB / HR

Fig. 71. Curves illustrating the derivation of the characteristic curve of the boiler-feed system

Selection of Speed-Control Points

Because considerable importance is attached to the use of adjustable speed on the boiler-feed pumps, it may be of value to discuss, at this point, the method of determining the required speed range and the selection of the various speed points in that range.

The purposes of speed adjustment are to save wear and tear by operating the pump at only the necessary load rather than at full speed continuously, and to save auxiliary power by eliminating unnecessary throttling of the pump output. To accomplish these purposes the speed range and control should be such that only the head needed for a given rate of discharge will be generated. The first step then is to determine the pressure-flow characteristic of the boiler-feed system.

The pump rating of 684,600 lb per hr at 1186 psi g already has been established. At the same capacity but under normal boiler pressure the discharge pressure at the feed pump will be 1092 psi g. Conditions at the low capacity end of the characteristic are not so readily determined but are arrived at as follows:

If the plant extension were laid out on the unit basis where one definite boiler or battery of boilers supplies steam to a specific turbine and is fed from one specific pump, or if the entire feed system were shut down as would be the case in the initial start up or after a complete emergency shut down, then the pressure required to start delivering water into the

boiler would be merely the pressure at the superheater outlet plus the static elevation between the pump and the boiler-feed drum. With no flow, or practically no flow, the friction losses in the feed system would be zero. In the operation of an inter-connected system of boilers, turbines, and pumps, however, the minimum pressure required in the feed system at any time will be determined by conditions in whichever boiler is steaming at the highest rating. Furthermore, as plant load drops off the boiler steaming rate will be reduced to some minimum value determined by operating experience and below that point one or more boilers will be banked rather than to further reduce the ratings on all boilers. With increasing plant load the opposite procedure is followed; the ratings on the steaming boilers is increased only to a predetermined value above which more boilers are brought into service. The pressure required at the low capacity end of the characteristic depends, in the design stage, upon the designer's judgment with respect to the probable minimum steaming rate at which the individual boilers will operate. For the Delray extension the pump discharge pressure at zero capacity was taken at 970 psi g whereas it would have been only 901 psi g on the "unit system" basis. The difference between the pressures of 970 psi g at zero flow and 1092 psi g at full flow is friction loss, occurring in the 4th and 7th-stage heaters, piping, feedwater regulators, economizer, and superheater. This is the basis of the characteristic curve of the system as drawn in Fig. 71.

The combined head that must be generated in the hotwell pump and boiler-feed pump at any capacity is equal to

1. The head required by the system characteristic beginning at the feed-pump discharge, plus
2. The friction loss between the hotwell pump discharge and boiler-feed pump suction, minus
3. The positive head at which water enters the hotwell pump from the lift pump.

With the system characteristic modified by items 2 and 3 above, the adjustable-speed characteristic which the combination pump must match is as shown in Fig. 72, which also gives the combined full-speed characteristic of the two pumps operating in series.

The minimum pump speed is calculated as that speed which will produce a shut-off pressure of 970 psi g at the feed-pump discharge. Maximum speed is required to develop the full rating of the pumps, that is, 1186 psi g at the feed-pump discharge with a flow of 684,600 lb per hr. Selection of the speed points consists in dividing the operating range from minimum to maximum into the available number of speed steps in such a way as to give rather close adjustment at low capacities and at the same time limit the magnitude of the pressure steps at higher capacities. The short diagonal lines in Fig. 72 which slope downward to the right and cross the pump system curve are sections of the combined pump characteristic at various constant speeds. They show how the pressure generated in the combined pump may vary as the speed is changed. For example the 1560 rpm section crosses the system curve at 475,000 lb of water per hr and 1043 psi generated head. If, at that same capacity the speed control were changed to the next higher point the speed would increase to 1590 rpm and the generated head would step up to 1083 psi; 40 psi more than needed by the system. This speed would be good until the flow increased to 521,000 lb per hr. If the pump were left running at 1560 rpm while the demand for water increased to 521,000 lb per hr the pressure would fall to 1013 psi; 46 psi below that required by the system. Closer speed steps mean smaller pressure fluctuations, but with a limited number of speeds available fine adjustment in one part of the operating range means coarser adjustment in some other part of the range. Figure 72 shows the speed steps adopted for the 75,000-kw Delray pumps. A photograph of the boiler-feed pump speed-control station is reproduced in Fig. 73.

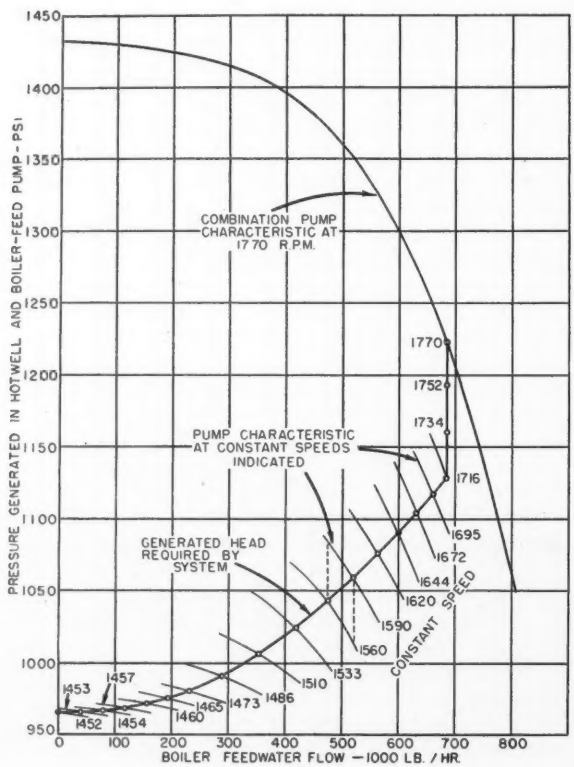


Fig. 72. Curves showing pressure generated in boiler-feed and hotwell pump at constant speed and at the speeds needed to satisfy the characteristic of the boiler-feed system

Feed Pump for Superposed Unit

The boiler-feed pump for the 10,000-kw superposed unit is the first motor and gear-driven pump installed in a Detroit Edison plant. A new 1200 rpm adjustable speed d-c motor of suitable capacity was available in Company stock and appeared to have no future use unless it were for driving the Unit 21 feed pump. Under these circumstances the gear drive provided an economical solution, and since convenient space could be found for the equipment the gear drive was adopted. The assembled unit is shown in Figs. 74a and 74b. In this case the pump speed is stepped up to 2475 rpm, maximum, which reduces the size and cost of the pump, partially offsetting the cost and space requirements of the

gear. There is no stand-by pump installed with the superposed unit.

Of special interest on this pump is the shaft-packing arrangement. All other feed pumps in the Delray plant are fitted with some form of labyrinth sleeve and soft packing. As a result of the high speed of the pump combined with its suction pressure of 500 psi g at 350 F it is considered necessary to provide a labyrinth pressure-break-down sleeve and leak-off chamber ahead of the normal shaft packing at each end of the pump. A pressure of 250 to 300 psi g is maintained on the leak-off chambers by means of a regulating valve in the leak-off line. This high-pressure leak-off water is piped into the suctions of the motor-driven boiler-feed pumps on 50,000-kw Units 12 and 13 with a waste connection to the overflow canal provided for emergencies.

Delray Plant

Feedwater Heaters

FEEDWATER heaters for the 75,000-kw units are of the multi-pass condenser type with tubes rolled into tube sheets at both ends. An even number of water passes is used so that inlet and outlet water connections are attached to the same water box. The return water box is arranged in a floating head to permit expansion and contraction of the tube bundle.

Four important differences exist between the heaters of the older section of the plant and those in the extension. They are

1. The use of welded steel shells in place of riveted and caulked construction.
2. The use of self-locking heads in place of heavy bolted joints on the high-pressure heaters.
3. Baffling of the tube bundle to provide a desuperheat zone for improving the "terminal difference" with respect to cycle efficiency on heaters operating with superheated bled steam.
4. The use of self-sealing partition plates in the water boxes to form the water passes.

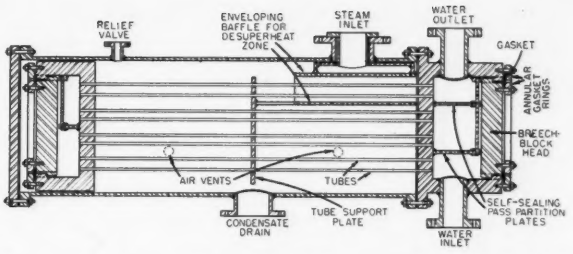


Fig. 75. Schematic drawing of the high-pressure feedwater heaters. This drawing shows four water passes whereas the high-pressure heaters installed with the 75,000-kw. unit have six water passes

A change in high-pressure head construction was practically demanded by the increase in working pressure while the other improvements are the natural result of advances in manufacturing and design technique. Figure 75 is a schematic cross-section of a high-pressure heater showing these construction features. Design data on all four heaters are presented in Table XV.

Judged by today's standards there is nothing unusual about the shell construction of the feedwater heaters, but in comparison with the corresponding units in the first section the new shells are relatively simpler, less expensive to fabricate, tighter against leakage of water or inleakage of air, and better able to take the strains set up in heating and cooling.

TABLE XV. FEEDWATER-HEATER DESIGN DATA*
DELRAY 75,000-KW UNIT 14

Stage number	13	10	7	4
Rated water flow, lb per hr.	485,660	684,600	684,600	684,600
Heating surface, sq ft.....	2640	2935	3535	3535
Number of passes.....	4	4	6	6
Water pressure drop, psi...	5.0	6.77	14.17	14.0
Tube diameter, in.....	⅝	⅝	¾	¾
Tube gage	18	18	11	11
Rated shell pressure, psi g..	25	50	150	250
Rated water pressure, psi g.	250	250	1200	1200
Water temperature in, F...	82	174.9	254.1	322.9
Water temperature out, F..	173.4	254.1	322.9	388.3
Terminal difference, F.....	5.0	3.0	0.0	—3.0
Welded construction	ASME U-69	ASME U-69	ASME U-68	ASME U-68

* Heater design data assume a heater-drain pump on the 13th stage.

Water heads of the high-pressure heaters are machined from one-piece steel forgings with tube sheets and shell flanges integral with the head. At the outer end the water heads are machined on the inner cir-

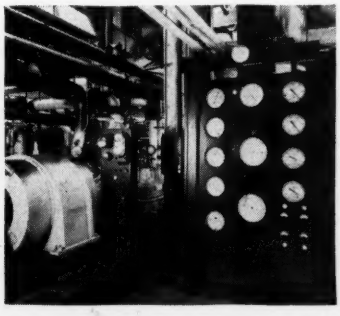
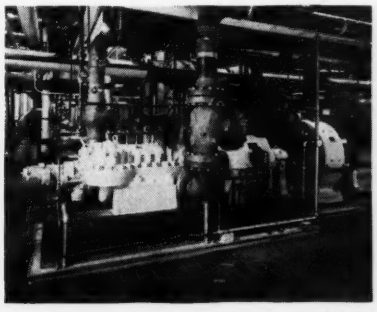
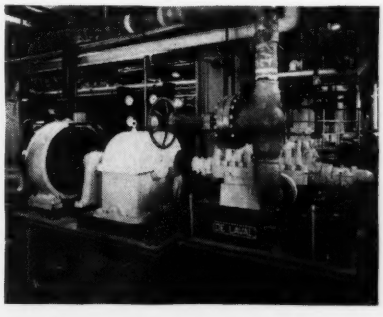
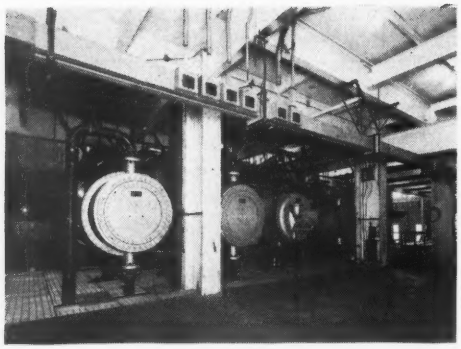


Fig. 73. Boiler-feed pump speed control station and feedwater heater gage board





Figs. 74a and 74b. Motor and gear-driven boiler-feed pump installed with the 10,000-kw. superposed unit; suction and discharge sides respectively



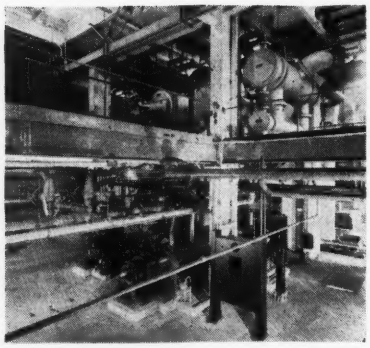


Fig. 76. Photograph during erection showing the 4th and 7th-stage heaters, evaporator and 10th-stage heater

Fig. 77. Construction view showing arrangement of feedwater heaters, evaporator, and boiler-feed pumps for 75,000-kw Unit 14

cumference to form hook-like projections which will match similar projections on the head cover. When the cover is inserted and rotated through a small angle, the corresponding projections come into line, much the same as in the breech-block of a heavy cannon. The hydraulic load on the head cover is then carried by the mating projections of the water head and the head cover so that no bolting whatsoever is required for that purpose. The joint between the water head and cover is sealed on the outside with a gasket which is held to the water head by means of a bolted hoop flange and to the head cover with another, smaller-diameter, hoop flange. An external view of the high-pressure water heads is reproduced in Fig. 76 which shows the 4th and 7th-stage heaters, evaporator, and 10th-stage heater during construction.

An enveloping baffle around the tubes in the last water pass constitutes the desuperheat zone in those heaters receiving superheated bled steam. The envelope protects the heater shell from the hot steam and confines the steam to a definite path where it is out of contact with saturated or wet steam and wet tube surfaces. In its action the desuperheat zone is, therefore, that of a gas cooler, and under favorable conditions the feedwater is heated to a temperature somewhat exceeding the saturation temperature corresponding to the heater shell pressure. This, of course, favors the heat cycle of the plant.

The self-sealing partition plates in the water heads are best understood by examining Fig. 75. The arrangement simply is one in which the friction loss through the heater tube bundle is utilized to hold the partition plate assembly together. Water pressure within the partitioned spaces is lower than the pressure outside the partitions. Light bolting is used merely to assemble the partitions and keep them in place when the unit is not operating.

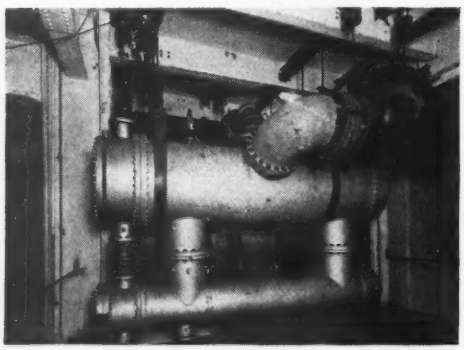
Heaters for the 10th and 13th stages are built in the standard fashion, using bolted head construction. No desuperheat zones are provided in these two heaters since the entering steam is wet at all loads.

Each heater is arranged for positive venting. A section of the tube bundle in the first water pass is baffled off to provide an "air-box" through which the non-condensible gas must pass as it leaves the heater. Since the baffled section is located at the bottom of the tube bundle any non-condensible gas that may exist in the heater will be swept toward it by the incoming steam and little, if any, stratification will occur. The upper sheet of the air baffle also provides a place where incoming drains from higher-pressure heaters may spread out and flash to facilitate complete deaeration. Fig. 77 shows the complete set of heaters and boiler-feed pumps as actually installed for 75,000-kw Unit 14.

The drain-cooler is merely a low-pressure heat exchanger operating with water on both sides of the tubes. It is supported in a novel way, shown in Fig. 78. In this picture the upper unit is the 13th-stage heater while the drain cooler is suspended below it by means of large flanged nozzles at the two ends. The mating nozzles at the right-hand end are dummies, installed only for supporting the drain cooler, while those at the left end not only support the drain cooler but also provide a small surge chamber in the drain circuit between the two units.

Evaporators

All main turbines are equipped with evaporators for the production of distilled water for boiler-feed make-up. In each case the normal evaporator capacity at



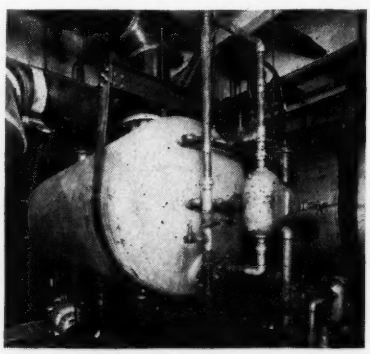


Fig. 78. Erection view of 13th-stage feedwater heater and drain cooler

Fig. 79. View of make-up evaporator from water supply end, showing feed valve and float chamber

rated turbine load is 1½ per cent of the boiler feed at that load. Helical-coil tubes make up the heating surface in the evaporators on the 50,000-kw machines while bowed tubes are used in the newer unit. In both styles the tube ends are held in rigidly positioned manifolds so that expansion and contraction causes distortion of the tubes themselves, tending to crack off scale accumulations. Aside from the deflections which occur in regular operation the evaporators are put through a "scale-shedding" cycle at least once per day. In this case the evaporator shell is drained and then filled with cold water to the top of the gage glass. Steam is then admitted to the tube bundle as rapidly as possible. The resulting expansion of the tubes causes a deformation that effectively cracks off the scale which falls to the bottom of the evaporator shell, there to be blown out through blow-down valves.

The normal steam supply to the evaporator tube bundle is taken from an extraction stage of the turbine. In the case of the 75,000-kw unit, steam from the 10th stage operates the evaporator while the evaporator vapor is condensed in the 13th-stage heater. A connection to the 7th stage provides steam at higher pressure for scale cracking, and for extra-capacity operation if required.

Raw river water from the general-service system is supplied to the evaporator through a float-operated feed valve shown in Fig. 79. The head end of the evaporator may be seen in Figs. 76 and 77.

Delray Plant

Condensers and Their Auxiliaries

THE CONDENSER for the 75,000-kw turbine is the first new condenser the Company has bought in several years. Modernization of Conners Creek was carried out by rather extensive improvements in tube sheet layout on the condensers already installed at that plant or available in salvage. How the condensers originally serving the 20,000-kw turbines were revamped for use on 30,000-kw units while condensers heretofore serving 30,000-kw and 45,000-kw turbines were rebuilt to serve 60,000-kw turbines was told at length in Combustion for May 1936. The importance of that story as it effects the Delray extension is that advancements in condenser theory and design which have been made and tried out during the last ten years are incorporated in the new condenser. These, together with collateral developments in chlorinating the cooling water supply and the reduction of condenser steam rate through cycle improvement, allow the use of only 53,620 sq ft of surface in the 75,000-kw condenser as compared with 60,000 sq ft in the older 50,000-kw condensers. Along with the reduced amount of heat-transfer surface it is necessary

Fig. 80. Tube sheet and inlet water box of 53,620 sq ft surface condenser

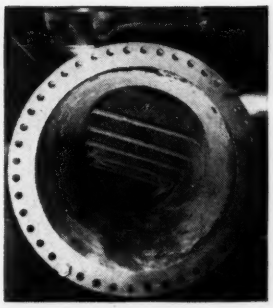
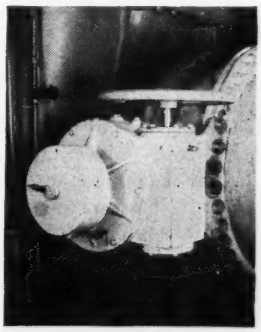
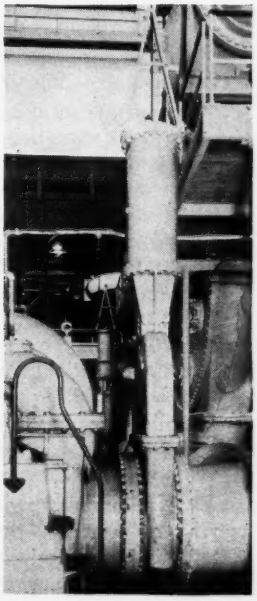


Fig. 81. Interior view of connecting piece between circulating pump and condenser inlet water box showing integrally cast guide vanes

to provide for only 67,000 gpm of cooling water as compared with 120,000 gpm on the 50,000-kw units. The reduced quantity of cooling water results in a substantial saving in auxiliary power.

The arrangement of cooling surface within the condenser shell is of utmost importance in obtaining the improved performance. Some 11,500 tubes, each ¾ in. dia by 24 ft long are used in two "folded tube-banks" as shown in Fig. 80. Tubes 1 in. in diameter were used on all previous condensers to facilitate cleaning with rubber plugs. Modern chlorination largely eliminates tube fouling, however, and in this case the smaller diameter tubes were selected because they permitted the use of a smaller diameter condenser shell which could be better fitted to the space available in the turbine base. Internal air coolers with external off-takes are located at the bottom of the tube bundle on either side. Generous steam lanes are provided for the incoming steam to penetrate the bundle, while adequate space has been left for free drainage of the condensate. Tubes are rolled into Muntz metal tube sheets at both ends. No flexible members are provided to accommodate the dif-





Figs. 82a and 82b. Manually operated butterfly valve and hydraulically operated gate valve used in circulating pump discharge on 75,000-kw and 50,000-kw units respectively

ferential expansion between tubes and shell, it being preferred to impose the expansion stresses on the tubes and tube sheets. There also may be some deflection of the tubes themselves, between support plates. The tubes are installed slightly bowed in the vertical plane with the high point midway of the length. This is to facilitate drainage of cooling water when the circulator is shut down.

The condenser shell and "bath-tub" hotwell are of welded steel plate construction which reduces weight and eliminates many feet of bolted joints that were necessary in the older sectional cast-iron shells. Water boxes are of cast iron. The condenser shell and turbine exhaust hood are protected against pressures above atmospheric by the installation of a 48-in water-sealed atmospheric relief valve. Protection of this sort is considered necessary to guard against the building up of internal pressure in the condenser in case of sudden failure of the cooling water supply.

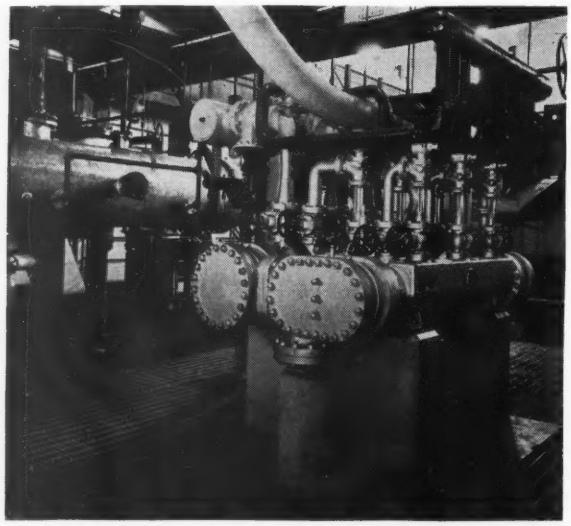


Fig. 83. Steam jet air ejector for 75,000-kw. condenser. The sealing steam condenser for the 10,000-kw. superposed turbine is visible in the background

For many years it has been Detroit Edison practice to equip each main condenser with two 48-in circulating water pumps. On the 50,000-kw machines the two pumps running simultaneously at full speed deliver 120,000 gpm. The reduced quantity needed for the 75,000-kw unit is just about the capacity of one of the 48-in pumps running alone, and for the first time in the history of the large Detroit Edison machines, the unit is equipped with only one pump. Operating records for many years back showed that from the standpoint of reliability one pump is enough, and the economy of installing one large pump as compared with two smaller ones together with the ability to use duplicate spare parts for this pump and the many others like it prompted the single pump installation.

Two other features of the hydraulic circuit are worthy of mention. One is the connecting piece between the pump and condenser water box; the other is the pump discharge valve. The water inlet connection pipe is made with integrally cast inside guide vanes. Without the vanes water would enter the box with a definite tangential component and set up swirls and eddys that would cause uneven distribution of cooling water to the tubes. The guide vanes are proportioned in such manner as to introduce the water into the box with uniform distribution across the face of the tube sheet, thereby supplying a full ration of water to each tube. A photograph looking into the end of the connecting piece is reproduced in Fig. 81 while a side elevation may be seen in Fig. 80.

A 48-in shut-off valve of the butterfly type is installed at the discharge of the pump to guard against a possible back-flow of water through pump by siphon action in the hydraulic circuit. This valve is manually operated through a hand wheel and gears to bring the butterfly disc into contact with a rubber seat ring. All previous installations used 48-in hydraulically-operated slide gate valves for this purpose. The two types of installation are compared in Figs. 82a and 82b.

Air Ejector Equipment

Out of twenty-three main turbo generators in the Detroit Edison system, the new Delray unit is only the second one to be equipped with a dry vacuum pump of the steam-jet type. All others have d-c motor-driven reciprocating vacuum pumps. The air ejector apparatus chosen for the Delray machine is a three element unit with three pressure stages per element, shown in Fig. 83. Capacity of the three elements working simultaneously is 1.65 lb of dry air per minute from an absolute pressure of 1 in. Hg. Steam used by the jets is condensed in an inter-and after condenser located in the main condensate circuit immediately after the hotwell pump. Inasmuch as the ejector must be put into operation before the main unit is carrying load, it was necessary to supply cooling water to the inter and after condenser by some auxiliary means. This is accomplished with a small by-pass from the boiler-feed pump discharge to storage. The lift pump and combination pump are started and the by-pass to storage opened to establish a flow of water through them. Then the ejectors are put into operation. As soon as the main unit has some load and there is an adequate flow of condensate the by-pass may be closed. The by-pass also may be used for close regulation of the pump at light loads, for artificially loading the pump during tests after overhaul, or for stabilizing operation when two or more pumps are running in parallel at light loads. When starting up the 75,000-kw machine it is possible to prime the condenser either from the vacuum header or by means of a specially installed priming ejector. The latter is a large single-stage ejector rated at 21 lb of air per min from 15 in. Hg absolute. Steam used by the priming ejector at the rate of 2300 lb per hr is discharged to atmosphere along with the air it removes from the condenser.

The fifth and concluding installment of this series will appear in the November issue. In it will be related some of the operating experiences with the equipment and operating cycle that have been discussed in the four installments already presented.

This article was written by the author for the benefit of a group of engineers in the Los Angeles Bureau of Power & Light who wanted a short outline of the methods used in making impulse tests and the purpose of making them. Much has been written on this subject but Mr. Short's explanation is so simple and clear that we are pleased to present it here. It gives the operating engineer an idea of the theory and practice involved in these tests without the necessity of wading through involved technical material.

IMPULSE TESTS—What They Are And How They Are Made

By CHARLES M. SHORT

Design & Construction Division
Los Angeles Bureau of Power & Light

THE PURPOSE of impulse testing is primarily to enable operators to co-ordinate insulation levels. Its ultimate aim is to give some basis for predicting insulation breakdown and controlling the location of flashovers.

The term "insulation co-ordination" means the establishment of insulation strength levels of apparatus or parts of apparatus on a system so that they are related to one another and to the voltages to which they may be exposed. As an example, such tests may be made on transformers and oil switches to make certain that the bushings flash over before the insulation is punctured or the internal parts are damaged. Some of the parts of a transmission system which require consideration of relative insulation levels are: transformers, switches, station busses and transmission lines.

Though simple in theory, successful application of insulation coordination has required years of research. Both laboratory and field experience has proved that equipment properly co-ordinated for one type of overvoltage, such as produced by arcing grounds, switching, etc., may not be co-ordinated properly for the type of overvoltage produced by lightning. Experience within the past few years has demonstrated that the most dangerous abnormal voltages are caused by lightning. Switching surges and arcing grounds are now recognized as of secondary importance in territory subject to lightning.

Wave shapes of surge voltages resulting from lightning disturbances on line conductors have been found to vary between the wide limits of from less than one to fifty micro-seconds from zero to crest voltage and the voltage may vary from a few thousand to over a million volts. The maximum voltage reaching the stations at the ends of a transmission line is determined by the insulation level of the line together with the tower-footing resistance.

Since the breakdown voltage of various insulating materials varies considerably with the type of impulse potential applied, it is apparent that tests at standard power frequencies would not be indicative of what might be expected under operating conditions. In order to be effective, surge tests must be made with surge waves closely approximating those to which the equipment will be subjected under operating conditions.

Systematic efforts at insulation co-ordination may be said to date from about 1926. Previous to that time most high voltage testing had been done at standard power frequencies because facilities for producing and recording surge voltages were not generally available. Static machines producing high voltages at low energy had been available for many years, but the violent disruptive effects of natural lightning were not reproduced until recently when methods were found for releasing abruptly large quantities of energy previously stored in capacitor units of high ratings. With the equipment available at present the duration of the discharge is limited to a few micro-seconds.

The problem of producing surge voltages was probably not so difficult as the problem of developing

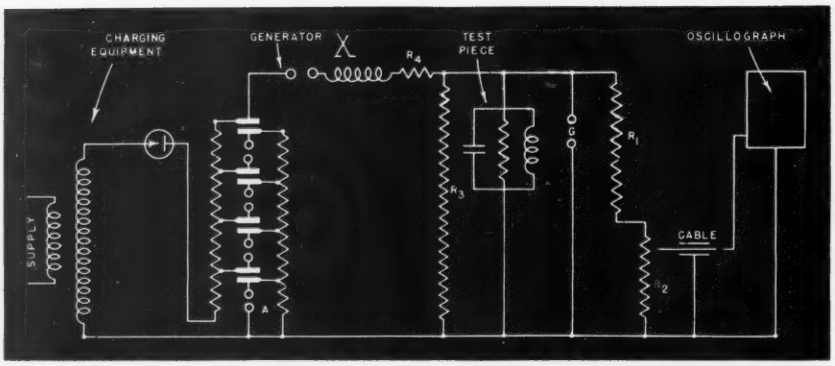


Fig. 1. Impulse Test Circuit. This is a simplified schematic diagram. The value of the resistance R3 and R4 and the reactance X determine the shape of the impulse wave. The rod gap G is a co-ordinating gap used for limiting or checking the magnitude of the applied voltage

a method of recording the extremely fast impulses. The high inertia of the magnetic oscillograph made it unsuitable for such purposes. The principle of the cathode ray oscillograph had been known for many years previous, but it was not until 1925 that it was improved and made suitable for this type of work.

Several types of generators have been developed for producing surge voltages. The most common is the Marx-Circuit type. Essentially, it consists of several condensers arranged for charging in multiple and discharging in series. A simplified schematic diagram of the circuit is shown in Fig. 1. The values of resistance R3 and R4 and rectance X determine the shape of the impulse wave. The rod gap G is a co-ordinating gap used for limiting or checking the magnitude of the applied voltage. Resistances R1 and R2 form a potentiometer arrangement for applying only a portion of the full voltage on the deflection plates.

Each capacitor unit is usually rated at about fifty thousand volts. The crest voltage value is controlled by the numbers of units in series and by the length of time they are charged. The maximum voltage which may be obtained depends on the number of units in series and is limited by the practical limitations of insulation. Voltages as high as ten million volts have been attained.

The current which may be obtained from a surge generator depends on the capacity of the units, method of connection and length of time involved in the discharge. At low voltages the units may be connected in multiple to obtain higher currents. Since the energy stored in a generator is completely dissipated in each discharge it is obvious that the current is in inverse ratio to the time involved in the discharge. Currents of fifty thousands amperes at five million volts have been recorded; the discharge lasting only ten millionth of a second. This is equivalent to about twelve million kilowatts of power, or approximately equal to the average output of all utility power plants at the present time.

The oscillograph is calibrated by applying a known voltage to the plates and noting the amount of deflection. If the voltage per inch deflection is e volts, then the actual voltage E of the surge can be calculated by the formula $E = \frac{de\,R1 + R2}{R2}$, where d is the deflection in inches.

The charging equipment consist of a transformer and a rectifier tube operating at about 50 kv. The instant of discharge is controlled by short-circuiting the sphere gap A.

In order to permit comparison of test results the A. I. E. E. has designated three standard types of surge waves to be used in testing. These are 1x5, 1x10 and 1.5x40 micro-second waves. The first figure denotes the time interval required to reach crest voltage and the second figure determines the length of time required for the voltage to decrease to one-half crest value. Both intervals of time are measured from the instant voltage is applied. The time interval is obtained from the oscillograms by comparison with a timing wave of known frequency. A graphical representation of the three wave forms is shown in Figure 2.

Among some of the factors affecting insulator impulse sparkover are:

1. Shape of wave
2. Polarity of impulse
3. Barometric pressure
4. Humidity

A wave with a steep front and rapid decrement requires a higher crest voltage for flashover than a wave less steep and of more duration. As an example, a 0.5x5 micro-second wave on insulator units will give a minimum crest voltage flashover value of about 50

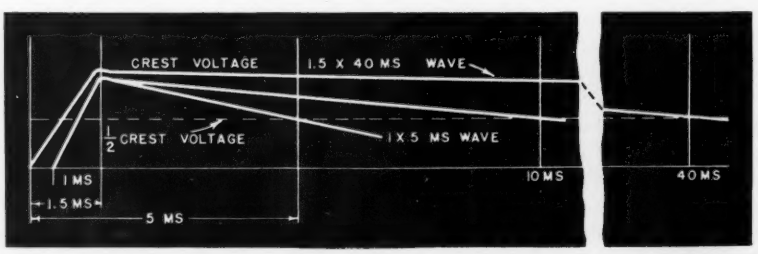


Fig. 2. Standard Waves for Impulse Testing

per cent above 60 cycle voltage flashover. Under those conditions the flashover is accomplished after about 3 micro-seconds time. Raising the crest voltage will, of course, reduce the length of time for flashover. A 1.5x40 micro-second wave will give a minimum crest voltage value of approximately 10 per cent above 60 cycle voltage flashover. The positive wave flashover voltage is lower than the negative. In specifying tests it is therefore important to state which polarity is to be used. Low barometric pressure and low humidity tend to reduce the value of flashover voltage, but the effects are so slight that these factors are not considered except in very precise testing.

There are two standard methods of testing usually employed. One is to apply an impulse potential and

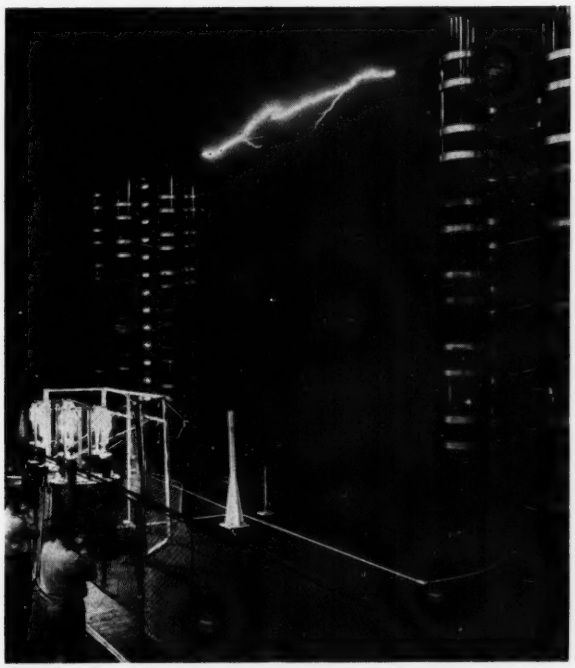


Fig. 3. A ten million volt impulse generator in action. This unit installed at the Pittsfield Plant of General Electric is similar to the unit being demonstrated at the New York World's Fair

determine the time for flashover. This is called the "volt-time" method. The second is to apply waves of different shapes and determine the minimum voltage which will just cause flashover 50 per cent of the time. This is called "the minimum wave, 50 per cent sparkover" method.

The 1.5x40 micro-second wave is generally regarded as satisfactory for use where it is desired to study voltage-time relations. Waves for this test are usually specified as 1.5x40 3 micro-second. This indicates that it is desired to know the minimum crest voltage at which a wave of that shape will cause flashover in 3 micro-seconds; timed from the initial application of voltage. A graphical representation of such a wave is shown in Figure 4.

In testing equipment having very low values of capacitance, such as a circuit breaker, the surge

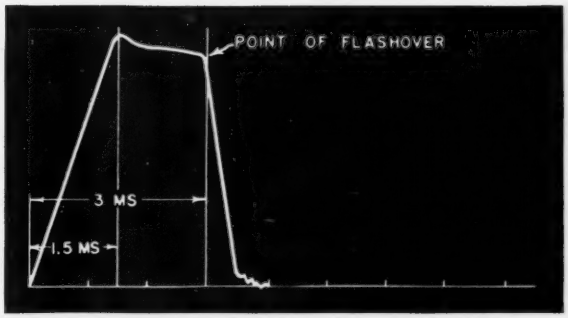


Fig. 4. 1.5 × 40—3 micro-second wave

generator constants can be adjusted beforehand to give the desired wave shape. Insertion of the test-piece in the circuit will not cause an appreciable change in the wave shape. That would not be true, however, in testing a piece of equipment having high capacitance, such as a cable. In that case a special circuit adjustment, taking into account the capacity of the test-piece, would have to be made.

Considerable advancement has been made in the technique of surge testing in the past ten years and research in that field is still being made. Nearly all large manufacturers of electrical equipment, some power companies and a few universities have facilities for making such tests. On the Pacific Coast Caltech and Stanford University have well equipped labortories for making surge tests.

Sewer Gas Engines Help Clean Up New York Harbor

PRODUCTS of the Worthington Pump and Machinery Corporation have been quite prominent among the equipment furnished to the City of New York's new sewage disposal plants at Coney Island, Ward's Island, and Tallman's Island.

The latter is the largest sewage treatment plant in the United States using internal combustion engines which operate on sewage sludge gas. Where sewage gas engines have been used previously they have been designed for electric power generation, but in this installation four Worthington engines, two of 845 hp. and two 460 hp. each, are directly connected to rotary blowers, and four smaller Worthington engines, through a system of gears, drive the raw sewage pumps, also built by Worthington.

To secure quality nickel alloys were widely specified in these engines to assure the strength, wear-resistance and stamina essential to the continuous operation demanded in this job of keeping the harbor waters free of pollution. A high test cast iron containing nickel is employed for cylinder heads, liners, pistons, valves and casings, and important uses are also made of nickel alloy steels, both cast and wrought.

The large timing gears in the Roots-Connersville blowers which form part of this installation are cast in a machinable nickel-chromium iron of over 40,000 p.s.i. tensile strength.

Educating The Power Plant Operator

By EARL W. MAURER

Lock Haven Mills
New York & Pennsylvania Co., Inc.,
Assistant Station Operator,

MUCH has been said and written, in recent years, by executives of power companies and industry, by editors of the leading power journals, and by various members of the engineering societies, concerning the urgent necessity for a satisfactory power plant educational program that will meet the needs of the men who constitute the operating personnel of the nation's power industry.

Much progress has been made along this line, both by the utilities and by the big private industrial concerns. Present indications are that the immediate future will witness a very large growth in educational programs, not only among the big companies but the smaller ones as well, who, unfortunately for years past, have not had the time nor the financial means, and in some cases lacked the initiative to carry them out.

Program Needed in Industrial Plant

The writer's ideas on an educational program for the power plant operator are based primarily from the industrial plant point of view, since it is in this type of plant most of his experience has been gained.

There are many daily problems faced both by utility and industrial operators that have a common solution. There are, however, many others whose factors are so changeable that no similarity exists. Now and then, abnormal conditions arise in the various processes of manufacture within the industrial concern which seriously affect the stable operation of the machinery in the power plant. The responsibility of meeting these situations quickly and efficiently rests with the operator on duty. His brain must move at least two jumps ahead of his hands or his feet. If it does not, he soon becomes a mere leaf in a windstorm of chance. An educational program, whose main objectives are in presenting efficient yet simple solutions to these everyday problems, is what the power plant operators are looking for.

Traditional methods of operation, which have long become habitual in many power plants, are rapidly being superceded by modern ones. These methods must be synchronized with modern thinking. The wide-awake operator is keenly aware of this fact. He must know the answers to a diversity of problems which have come up in the last few years as a result of the changes made in power plant equipment and its operating procedure. The recent advent of high-pressure, high-temperature steam to both the utility and industrial power plants bringing with it new types of steam generating equipment, new types of turbines, new types of auxiliaries, is but one of the many of these changes. An operator's past experience in successfully operating the old equipment is no absolute guarantee he will likewise operate the new. He must be thoroughly trained.

No educational program would be complete if provision was not made to teach the practice of safety first to all members of the operating staff. Improper operation of new and unfamiliar power equipment can often lead to serious and costly accidents, both to the operator and the machinery. Taking a flying chance on operating such equipment is, in the writer's opinion, courting suicide. It is absolutely necessary that the operator be given as complete instructions as is possible, either from the management or the equipment manufacturers, concerning the correct methods for safety in operation. Emphasizing, also, the constant practice of keeping power machinery clean, is a splendid advertisement in safety first. An ounce of prevention being better than a pound of cure, is the cure.

It has been the writer's experience in talking with a number of power plant operators, that the overwhelming majority of them are in favor of some type of educational program to help them in their work. In one instance, the proof of this was remarkably demonstrated in the industrial power plant where the writer is at present employed.

Preparations of Operators for New Equipment

This company's decision to increase steam pressure temperature and generating capacity in one of the boiler houses, and to build a completely new, modern, turbo-generator room was followed by a personal decision on the part of the head of the steam department to conduct a series of class discussions with the operators on the new setup. This was begun about four months before the new turbine room went into operation. This gave the operating staff an opportunity to learn the multitude of revised operating methods incorporated in the new design.

Classes were held once a week during the winter months of 1937-38 in the auditorium of the company's club house, beginning with a general discussion of all steam generating equipment and auxiliaries, both new and old, and their proper method of operation. This was followed by a series of detailed discussions on every piece of equipment installed in the new turbine room. Emphasis being stressed upon their proper care and safety in operation. The new extraction system, which supplies bled steam from the turbines for process use in the paper mills and for feedwater heating, received particular attention.

Since the classes were held jointly for both the boiler room and turbine room operators, much better results were obtained. Each had an opportunity to understand the other's problems. Questions were asked by both sides and were answered—if humanly possible. Worthwhile ideas from the operators were welcomed and a number were presented. Time has proved that the results of this educational program has justified the endeavor. It has paid dividends both to the company and to the operators.

An educational program to suit the needs of the operator in any power plant can be made successful. All it takes is cooperative effort, a simple understandable schedule, effectively applied at the right time.

The PRACTICAL ENGINEER

DEVOTED TO PLANT OPERATION and MAINTENANCE

A. W. KRAMER, EDITOR

HOW IT WORKS?

Last month one of our readers asked for assistance in devising a 5 day, 40 hr. week work schedule. He told of the difficulties his present work schedule involved and wondered whether we could help him in working out a new system.

This question was presented in the "Question and Answer" section of the August issue. We thought that among our many readers there might be some who could offer "J. M." the benefit of their own practical experience along this line and we were not mistaken—there were. We did not, however, anticipate the overwhelming response to this request for help. While we were able to publish only one reply in this issue, we have received dozens of letters and they are still coming in. Many of these replies indicate that they realize the difficulties "J. M." is "up against" and express their willingness to be of help to him.

We take pleasure in citing this instance to show how the Practical Engineer can be of help. By the time this reaches print, J. M. will have all the data for an adequate and satisfactory solution to his problem and the published answers in future issues may be of further help to others confronted by similar problems.

Remember, as an operator in a power plant, you are in a position to give as well as receive information from this section. The more it can be made an "open forum" the better we will like it, and we know you will too. Furthermore, if there are things in it you do not like or don't agree with, don't let that stop you from writing. Tell us—we can take it.

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A Section of Power Plant Engineering

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53 WEST JACKSON BLVD., CHICAGO, ILL.

Post vacation thoughts and other things. Why editors climb mountains or do they? Theory and practice in sports and in engineering. The relation of fishing to engineering. Finally, mud turtles—how they can be made stepping stones to success.

MOUNTAINS, TURTLES, AND ENGINEERING

AMONG the numerous vices which the writer has acquired in the course of time there is one which, when it manifests itself, never fails to arouse consternation among his acquaintances. From their viewpoint it is a strange malady for which there is no accounting.

Every year, at approximately this time of the year he suddenly disappears from civilization. The last his friends see of him, he is walking off with a strange looking pick in his hand, a coil of rope around his shoulder and dressed in a curious array of heavy woolen clothes—in July, mind you.

To be sure, by this time most of them know that he is off to go mountain climbing in the Canadian Rockies but, sensible people that they are, they still shake their heads and, though they

The Last They See of Him

try to pass it off lightly, they regard him with much the same mixture of pity and compassion that they feel for the inmates of an insane asylum. The only difference between him and the inmates of the booby-hatch, they feel, is that he is still loose.

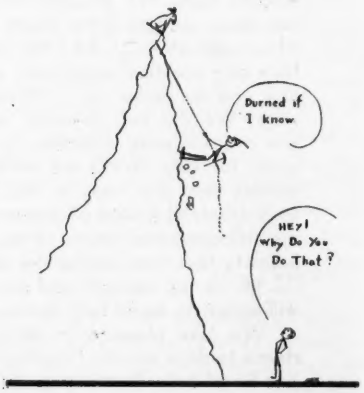
Under ordinary circumstances these things would not be mentioned here but it so happens that your editor has just returned from one of these sojourns in the mountains and the opprobrium in which he is regarded hangs heavy upon his head. The sly glances of his associates, the knowing winks to each other, the obviously forced species of humor with which they greet him upon his return cause him to wonder whether they may not be right. After all, he cannot answer their first and simplest question—"Just why do you climb mountains?"

Somehow the question reminds him of the time worn joke about the man who had spent 50 years tapping the wheels of the railroad coaches as the trains stopped at stations. Learning of this remarkable record of service an admiring traveler stopped to congratulate him and then as an afterthought asked, "And just why do you tap the wheels with your hammer?" To which the answer was, "Well, I'll be durned if I know."

So too with mountain climbing. Why do people climb mountains? Honestly we can't tell you because we don't know ourselves.

But why do people do anything? Why do some people play golf? Why do others drive frantically from one side of the continent to the other when they might be sitting leisurely and comfortably at home? Why don't they stay home and work?

After all, there seem to be some sensible people in the world; Dan Gutleben, for example, of whom we wrote last month. When Dan goes on a vacation do you suppose he goes clambering up the sides of rocky cliffs or wears himself out trudging over endless glaciers and snowfields? Not on your life. He goes out visiting other sugar refineries. Why? Don't ask us, ask Dan—maybe he can tell you and again maybe he can't. The only real answer probably is, that he is made that way.



Why Do People Climb Mountains?

Mountaineering may be an outlandish sport to many people, but to the writer it offers the exhilaration and opportunity for accomplishment required by certain inborn traits, and in some respects it resembles engineering. Like engineering, mountaineering has both a theoretical as well as a practical side. The writer knows a number of excellent technical mountaineers—men (and women, too) who are experts in the technique of climbing. This type of skill and knowledge is very necessary, but there is another side to climbing which demands qualities of a different order—practical qualities involving endurance, patience, and the ability to accept defeat in good spirit. The best mountaineers, naturally, like the best engineers, are those endowed with a well balanced measure of both qualities. Arm chair mountaineering, while quite sufficient for a winter evening's pastime, is quite inadequate when it

comes to making a first ascent of a major peak.

The same thing of course is true in engineering. There are many fine, technical engineers capable of working out a difficult engineering problem on paper with remarkable precision. Such men are very necessary and many of the major developments in engineering are due to their skill and knowledge. Yet, when confronted by a practical problem which does not conform to those set forth in the text books, these same men are often quite helpless. Indeed, a letter which comes to us as these very lines are being written tells of an engineer who was asked by a member of the operating department whether a certain pump could be used for a certain type of service. After figuring for three days this engineer called back the operating department and told them that it was impossible. Whereupon the operating department said "the heck it is," we have had the pump connected and are running it.

He Caught a Strong Healthy Four Pounder

The qualities which make a good practical engineer are often as inborn as those which make a man a good mountaineer, or a good farmer, or indeed one proficient in any field of human endeavor.

All of which reminds us of the story of a young man who rode to success on a turtle. The turtle, however, as will be apparent from the following, was quite incidental—the young man obviously had the qualities which would have "got him there" anyway.

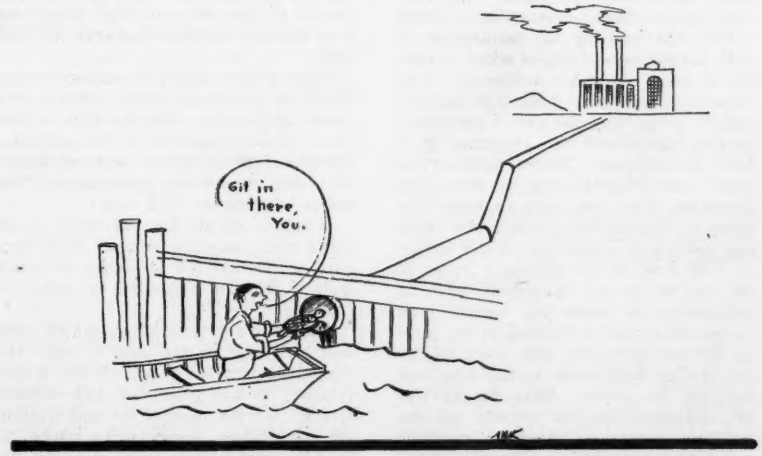
About 1896 in Erie, Pa., the Erie Electric Motor Co. of Erie, Pa., operated a street railway which was served by a power plant consisting of approximately five 150 hp. boilers, one 500 hp. Ball engine and three 200 hp. tandem compound engines, running condensing. Water for boilers and condensers was taken from the lake. Around the intake was a crib. This water flowed from intake in crib through a 10 in. line about 1200 ft. to a reservoir, from which it was pumped to the power plant. In time this 1200 ft. line choked up with mud,—barely a trickle came through. This necessitated cutting in on city water and the cost of such service was over $300 a month.

Meanwhile, for about 15 months, various things were done to open the clogged line. Under the direction of Jos. F. Brady, vice president, and H. F. Willron, general manager, various methods were tried. The use of air and steam at moderate pressure was given up after a few attempts because there was fear of blowing up the line.

Meanwhile, in the power plant was a young man who had been in the employ of the company since he was fourteen. First, he had worked as conductor; then, at his own request, he was put into the power plant—he wanted to be an engineer. At this juncture he was an oiler. Also he was red headed. When we tell you his name was Nelligan, you'll know he was a young man of promise.

One day V. P. Brady suggested to the oiler that he would like it if he would set his thoughts to working up a scheme to open that clogged water line. Knowing the history of the various attempts that engineering and managerial heads had tried, only to meet defeat, Nelligan suspected the request was made jokingly and so told Mr. Brady, "Surely you're foolin'." Brady said he was serious and really wanted him to think upon it.

A month or so later, Nelligan went fishing, caught a fine, strong, healthy four pounder and landed him quickly. Then he thought, "By golly, you're strong enough to wiggle your way through that long pipe," and he was struck with the realization that maybe he had an idea. But, no, only a bare trickle of water came through the pipe. It was filled with mud—not water. A fish would smother in mud. Mud—MUD—By golly, a mud turtle!



—Then Lifted the Turtle Up to the Intake of the Pipe

A few miles up the lake shore lived an old recluse. He fished—also he dug for turtles. He had two—one slightly larger than the other. Nelligan insisted on paying a dollar for them. He took them home; drilled four holes near the corner of the top shells, wired on each a halter, similar somewhat to the halter boys used to put on kites, then he wired the turtles together in tandem—the smallest one in the lead.

He then got 1800 ft. of trawling line, a little heavier and stronger than No. 18 dark C wrapping twine, and wound this on a reel. With the reel, line and turtles in a basket he went down to the intake crib in the lake. He let the turtles out onto the sand in the crib, attached the trawling line to both halters, then lifted the turtles up to the intake of the pipe line. This intake was below the lake surface level about 1 ft. It ran straight down about 4½ ft. and elbowed to the 1200 ft. line to the reservoir. As the turtles traveled he reeled out the line. A few feet in they stopped. He remembered if you pulled a calf's tail he would run forward. Gently he twitched and pulled the line. Then he had to "pay out". In seven hours they got through to the reservoir.

The turtles had carried the trawling line through. They were unhitched; a slightly larger rope was pulled through by the trawling line; finally a cable and brushes and the line was in service.

V. P. Brady deposited a thousand dollars in the bank to send Nelligan to an engineering school. Entrance examinations stuck him—so he had a tutor, the late Professor Burns, teacher of Civil Government, Central High School, Erie. Mr. Nelligan is the D. J. Nelligan, 228 W. Second St., Erie, and chief engineer of Schaffner Brothers Co., meat packers, of that city.

Years later in order to tap a sewer at his home, builders had to pipe around one shoulder of a large boulder. Through insufficient "fall" the sewer finally clogged. A "snake" could not be put through because of this "detour" in the line around this boulder. Mr. Nelligan trapped a mouse and kept him two weeks, meanwhile building out of piano wire a harness. To this harness he attached a spool of strong black thread he had waxed. On a Saturday, the children home and all a twitter, he put Mr. Mouse in the drain, paying out line as needed, and when a stop was made he would pull gently, then on the mouse would run. The children were watching the other end. He said the whole neighborhood knew when the mouse got through.

It may well be said that a turtle took this engineer to success.

FOR THE PLANT ELECTRICIAN

Electric Service Entrance and Metering

THE "SERVICE ENTRANCE" for receiving service from the utility supply system is the "gateway" through which the electric supply enters the wiring system in homes, factories, and business houses. The service entrance includes a cabinet containing the main disconnect switch and fuse for the protection of the wiring system, the conductors extending from the service cabinet to the outside of the building and provision for the meter.

The old style service entrance employs the use of an open outlet consisting of rubber covered wires which emerged through the outside wall in porcelain tubes. An open meter loop with an exposed knife switch and fuse block was generally mounted on a wood board. With the introduction of conduit for enclosing the service conductors, came the development of enclosed safety service switches.

During a period of years, numerous changes were made in service switch design, mostly due to the varied requirements of the utilities for accessibility of main fuses and for meter testing facilities. The object of all interests was to provide maximum possible safety so as to minimize exposure to shock when replacing fuses and to reduce fire hazards.

As pointed out in a recent issue of the Union Electric Magazine by R. A. Lea, many utilities experienced difficulties in obtaining meter readings on the premises. This led to the placing of the meter in an outdoor box where the meter would be accessible at all times. In 1931 the National Electrical Code recognized the placing of the meter ahead of the main switch and fuse and this metering was called the "New Meter-Switch-Fuse Sequence."

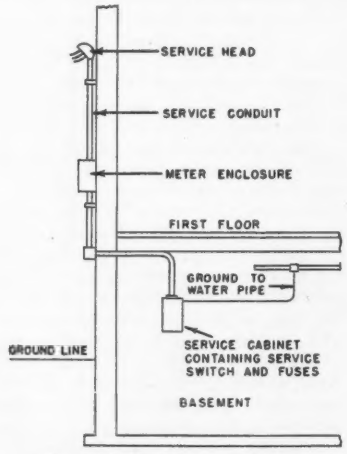


Fig. 1. Typical service entrance

Meter sequence merely means the order or sequence in which the switch, fuse and meter are connected to the supply line. From the beginning experience has proved the merit of placing the switch ahead of the fuse but not necessarily ahead of the meter. There are only three meter sequences, which are:

Switch-Fuse Meter (the old sequence).

Switch-Meter-Fuse (called the modified sequence).

Meter-Switch-Fuse (the new sequence).

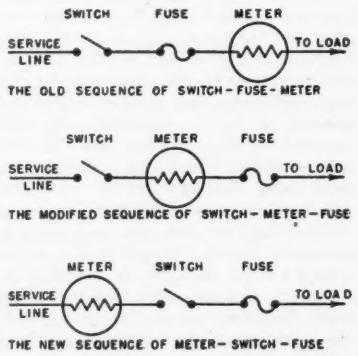


Fig. 2. One line diagram of meter sequences

The old sequence of switch-fuse-meter was the first used and remained in vogue for many years. The switch-meter-fuse sequence came into use in 1930 and although in the direction of progress, it did not entirely accomplish the desired results in protection and it further tended to complicate unnecessarily the service equipment. The new meter-switch-fuse sequence with meter outside the building has advantages to both consumer and utility which makes it the most desirable sequence. The meter is separated from the service switch, permitting the use of simplified service equipment and resulting in a safer installation. Better public relations result from the fact that the utility employee does not have to enter the home or disturb the customer for reading, testing or inspection of the meter.

The new meter sequence requires the use of special equipment such as enclosures or bases for socket type meters which are furnished by the public service company and installed by the wiring contractor at the time the building is wired. Metering devices are installed on the outside of the building except in cases of multiple metering where it is necessary to group the devices inside. Service entrances should of course, at all times comply with the rules of the National Electrical Code insofar as the character and size of conductors used is concerned and as regards splicing. These vary somewhat for different types of load and service so it is always well to look them up so as to be sure that they are complied with.

Notes on Motor Maintenance

By Thomas Trail

WHEN disassembling motors it is advisable to carefully mark the various leads and parts so as to avoid the possibility of making a mistake when reassembling the motor. The motor leads should be marked with small tags so as to identify them when the motor is reconnected. These small tags, made of cardboard, may be purchased for a small sum of money in stationery stores. Tags should also be used to mark brush leads, if the motor is so equipped and if they are to be disconnected from the brush holders. The field coil leads should be marked too, if they are to be disconnected.

Other details of the arrangement of parts should be noted and marked on a sheet of paper, or preferably cardboard, because it is more durable. Sometimes the end bells of the motor may have been previously shifted from their normal position because of the manner in which the motor has been mounted. Some other details may be: the number of washers, if any, on each end of the rotor shaft; the position on the shaft of the pulley, gear or other part, if one is present; the position of the brushes if the motor is so equipped, and the amount of rotor end play.

REMOVING ROTORS FROM MOTORS

Before attempting to remove a rotor from an electric motor it should be carefully noted in what direction the rotor should be moved through the stator if it is necessary that it be moved in only one direction. Caution in this regard may prevent serious damage to the windings of either the rotor or the stator. Some motors are equipped with a rotor fan that is of such diameter that it will not pass through the stator between the field coils.

The writer helped to disassemble a 40 hp. d. c. motor recently and it was noted at the time that the ends of the armature coils, opposite to the commutator end of the armature, were so shaped that they would not pass through the stator between the field coils.

Caution should be exercised at all times when handling rotors. It is very easy to damage the insulation of rotor coils if they are permitted to strike objects.

Recently a d. c. motor-generator rotor had been sent to the shop to have the commutator turned down. When it was returned it was placed on two wooden trestles for the purpose of undercutting the commutator segment mica insulation. In placing the rotor in position on the trestles some of the insulation on a

couple of the armature coils was damaged. It was then returned to the shop for repairs to the coil insulation. This unnecessary extra work could have been avoided had more caution been exercised in handling the rotor.

Calculating Temperature from Resistance Changes

By Eugene George Key and Michael J. Coppola

SOMETIMES IT becomes convenient to find the temperature of a piece of electrical equipment, particularly when that equipment is being tested for its temperature rise characteristics after a period of use. Testing the temperature with a thermometer or with a thermocouple or pyrometer gives the temperature in only a few isolated places. The best average that is possible by this method is the average of several readings, some or all of which may be influenced by air currents or for some other reason will be only an inaccurate approximation.

One engineer must have realized the deficiency of this method when he derived a formula for calculating the change in temperature when the change in resistance is known, but he applied his formula for only one kind of material—standard annealed copper—and for only centigrade temperatures. Although this application covers the majority of places where it could be used, there are occasions where a more extensive application would be convenient.

This formula considers the fact that the resistance of materials decreases in definite steps as the temperature is lowered. This is not strictly true, but it is true within a very small variation that is never considered in practical calculations. The resistance of copper, then, if the temperature is lowered sufficiently, would become zero at some temperature determined by a straight line which marks the change in resistance over a range of temperatures. In standard annealed copper, the resistance would, theoretically, become zero at 234.5 deg. C. below zero. Actually, the resistance line curves before it reaches this temperature, but this curvature takes place at a temperature far below that obtainable except in processes such as liquification of air.

Neglecting this resistance curvature for all materials, we may use the formula:

$$\frac{R_1}{R_2} = \frac{M + T_1}{M + T_2} \qquad (1)$$

where T_1 is the temperature at which the resistance is first measured, R_1 is the resistance at this temperature, T_2 is the temperature required, R_2 is the resistance at this temperature and M is the numerical value of the temperature at which the material in question would theoretically have a resistance of zero ohms. M for standard annealed copper, is 234.5 in C degrees. This formula uses the geometrical law that the corresponding sides of two similar triangles are proportional. R_1 and R_2 are corresponding sides and $M + T_1$ and $M + T_2$ are also corresponding sides of similar triangles, as indicated in Fig. 1. In this formula, M is always used as a positive number, but T_1 and T_2 are positive only if they are temperatures above zero and negative if below zero.

Suppose, for example, the resistance of a piece of electrical equipment is 10 ohms. It has not been used for some time, so the 10 ohms is measured at room temperature of, say, 20 deg. C. After it is used for a time, the resistance has increased to 10.5 ohms, and the new temperature of the equipment is desired. The conductor is steel wire, whose resistance, according to Table I, theoretically is zero at —215.3 deg. C. M, therefore, from the table, is 215.3. Inserting the values in (1):

$$\frac{10}{10.5} = \frac{215.3 + 20}{215.3 + T_2}$$

from which $T_2 = 31.77$ deg. C.

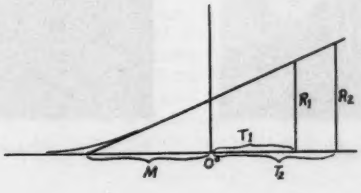
Table I—Temperature Constants for Conducting Materials

	Temperature Constants (M)	
Conductor	F	C
Silver, pure annealed	405.6	243.1
Copper pure annealed	385.6	232.0
Copper, annealed	416.7	249.3
Copper, hard drawn	417.4	249.7
Copper, standard annealed	390.1	234.5
Aluminum (99.5% pure)	391.5	235.3
Aluminum (commercial 97.5% pure)	379.1	228.4
Iron (approx. pure)	255.8	159.9
"E.B.B." iron wire	352.8	213.8
"B.B." iron wire	355.7	215.4
Nickel	256.2	160.1
Tin (pure)	373.2	225.1
Steel wire	355.5	215.3

Table I shows values of M for both Centigrade and Fahrenheit scales. Use of these values will simplify calculations in the same way as in the problem illustrated. Should other materials be used that are not included in Table I, the value of M may be found by the formula:

$$M = \frac{R_1T_2 - R_2T_1}{R_2 - R_1} \qquad (2)$$

For pure annealed silver, in Table I, the value of M is given as 243.1 in Centigrade units. This value was found in the following manner:



Pure annealed silver with a resistance of one ohm at 20 deg. C will have a resistance of .924 ohms at 0 deg. C, since its resistance decreases .0038 ohm per degree. Inserting these values in (2):

$$M = \frac{(.924)\ (20) - (0)\ (1)}{.076} = 243.1$$

Notice that M is found to be positive, which means that it is a value below zero. If it has been found to have a negative value, the theoretical temperature at which the resistance would be zero would be above zero and the formula might be useless unless the value was far above the ordinary working temperatures.

Converting Centigrade and Fahrenheit

By Stanley F. Davis

IN READING the various technical magazines and text books that I have had occasion to refer to, I have often wondered why the following method of converting the readings of the Centrigrade and Fahrenheit temperature scales were not shown.

$$C = 5/9\ (F + 40) - 40$$
$$F = 9/5\ (C + 40) - 40$$

where C = reading of Centigrade scale
F = reading of Fahrenheit scale

The advantage of the above method is that you have only to remember that 40 is *added* to the reading to be converted then multiply by the proper factor 5/9 or 9/5 and then *subtract* 40.

With the usual method shown in the text books and trade periodicals one forgets if the constant 32 is added or subtracted before or after using the conversion factor.

The first method leaves no doubt—you always add 40 first, then multiply by the factor and finally subtract 40.

Preventing Corrosion of Underground Cables

By W. E. Warner

CORROSION of underground cables drawn into ducts is sometimes serious. The British Post Office Department uses petroleum jelly as a lubricant when drawing in. This has been thought to assist corrosion, but it was found that if a silicate inhibition was added to the petroleum jelly used corrosion was entirely prevented while the lubricating properties were not affected. This has been used for a sufficient length of time and under sufficiently adverse conditions to prove that, provided silicate is added, petroleum jelly will not cause corrosion but will help to prevent it. In all cases where it is necessary to use semi-liquid lubricants where they must remain long periods a small addition of white lead or zinc oxide will largely prevent corrosion developing.

An Electric Safety Device For Oil Fired Boilers

THE IDEA of electric ignition devices for oil fired boilers is not new. In place of the torch commonly used to ignite the atomized fuel forced through the burners various electric devices have been developed and tried since the open flame of the torch as always been more or less a source of danger in the oil charged atmosphere of boiler rooms. These devices, which depended upon the use of spark gaps, arcs or resistance wires were never entirely satisfactory and the use of the open torch has of necessity persisted.

With the development of modern high pressure boilers the need for a reliable safety ignition device becomes really imperative. The effect of the extreme high pressure atomization of the fuel necessary for the high output of the burners is to cool the ignition device to such an extent that they are unable to ignite the oil, especially when starting up from a cold state. Furthermore, fuel oil of low inflammability, unless preheated, renders it necessary to raise a large superficial volume of vapor to a high temperature if instantaneous ignition is to be effected.

Another development to complicate the ignition problem, especially on ship board, was the enclosed boiler casing involving the introduction of combustion air at increased pressure directly into the combustion chamber. Since with this arrangement no doors could be opened, a device was required which rendered it possible to ignite the gas tight burners without flames or gases of combustion escaping from the boiler.

An interesting solution to this problem is a recent European development described in the Siemens Review.

In connection with their patent rights concerning the construction of Benson high pressure boilers Siemens-Schuckert have undertaken the introduction of a new electric safety ignition device for oil-fired boilers as proposed by Bohn. The ignition element consists of a so-called flame cartridge, the chemical contents of which produce a tongue of flame of 3600° F., which burns for a sufficient length of time. For reasons of safety the flame cartridge can only be fired in conjunction with an electric current. Figure 3 illustrates the action of the electric ignition device. From the cartridge, which is introduced into the combustion chamber by means of a rod, a flame jet is projected at the instant of firing into the mixing chamber. Here, the oil issuing from the burner comes into contact with the flame and is ignited. Duration, temperature, and length of the flame can be controlled by varying the contents of the cartridge.

In practicing the former customary but dangerous method of lighting the boiler by means of a torch, burning oil could rarely be prevented from dropping on the oily boiler footplate (Fig. 1). In conjunction with the new safety ignition device (Fig. 2) a bushing which can be closed by a cover, is provided, through which the ignition cartridge is introduced into the combustion chamber of the boiler by means of a so-called ignition rod. This is visible in Fig. 3 in the lower part of the boiler shield. In the operating position the ignition rod makes contact with the source of current by means of a plug and socket built into the bushing. The flame cartridge is fired by pressing the push-button, and burns for 6 sec. During this period the fuel oil atomized in the burners reaches the mixing chamber and is ignited by the flame of the cartridge. Hereupon,

Fig. 1. Use of torch is a source of danger in lighting an oil fired boiler

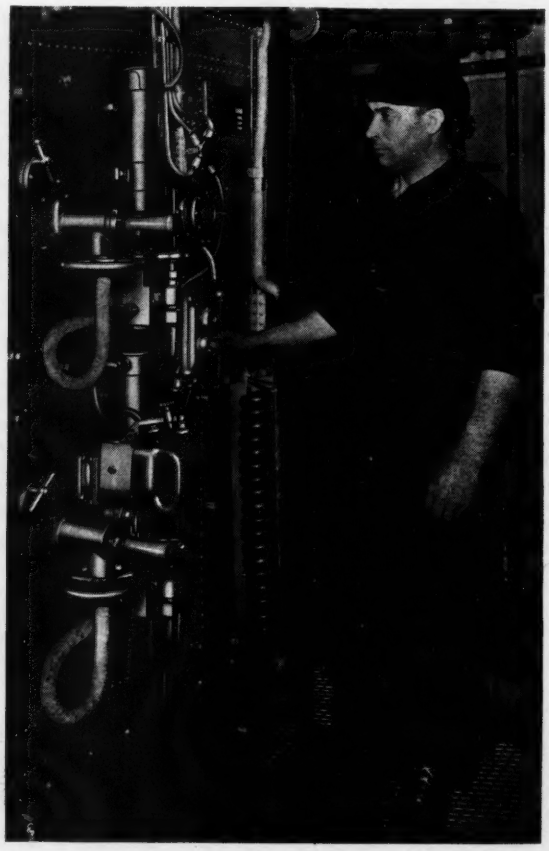


Fig. 2. New safety ignition by pressing an electric push button

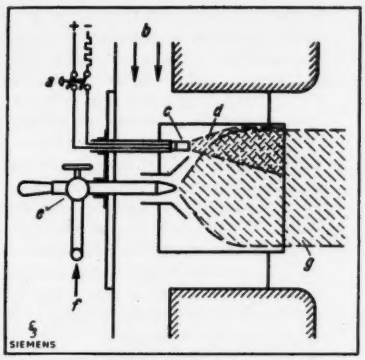


Fig. 3. Details of the Electric Safety Ignition Device. a, push button; b, air inlet; c, flame cartridge; d, flame jet; e, burner; f, fuel feed

the ignition rod is withdrawn from the bushing. An internal spring-controlled sealing cap automatically closes the opening of the bushing, and prevents the escape of compressed air or gases.

This device has been installed in a large number of the most modern German ships and also on land boilers, and has proved fully successful under all conditions. In further development of the design discussed above, the apparatus can be provided with a device for scavenging the combustion chamber with air before lighting up, in order to eliminate all risk of explosion due to residual gases.

The Handiest Steam Flow Rule

By W. F. Schaphorst

WITHOUT DOUBT Napier's Rule is the "handiest" steam flow rule, and perhaps it is the most used. Yet I find that many steam users do not appreciate its value and usefulness. It is used, generally, wherever steam is allowed to flow directly from high boiler pressure into the atmosphere, as in furnaces for creating draft, in soot blowers, in heaters, oil burners, etc.

Here is the rule: "To the steam gage pressure in pounds per square inch add 14.7; then multiply by the area of the opening in square inches and divide by 70." The result is the weight of steam in pounds flowing through the opening every second.

In order to make this rule a little more applicable to many power plant engineering problems I have converted it into this form: "To the steam gage pressure in pounds per square inch add 14.7 and multiply by the area of the opening in square inches; then multiply by 0.257; and into the result divide the number of pounds of water evaporated into steam in the boiler or boilers per pound of fuel. The result is the cost of steam in dollars per 10-hour day."

Thus for example: Find the cost of steam per 10-hour day flowing through ½-in. round opening for creating draft in a furnace where the gage pressure is 100 lb. per sq. in.; fuel costs $4. per ton, and 8½ lb. of water are evaporated into steam per pound of coal.

It is easy to figure or determine by means of tables that the area of a ½-in. round opening is 0.196 sq. in.

Substituting in the foregoing rule we get:

$$\frac{114.7 \times 0.196 \times 4 \times 0.257}{8.5} = 272$$

I carefully checked this rule a number of years ago in a university engineering laboratory and found that it gave surprisingly accurate results. A colleague inserted an orifice in a pipe line in such a way that all steam passing through the line was compelled to pass through the orifice. A gage was placed in front of the orifice, and another gauge behind it, and the steam was then condensed in a surface condenser. The back pressure was maintained at atmospheric pressure, or "zero gage."

By weighing the condensate after a given time it was possible to check the accuracy of Napier's formula by substituting the known figures and determining the only unknown—the diameter of the orifice. The orifice was not shown to me, consequently I did not have the least idea in advance as to what its diameter might be.

Upon inserting the test figures the formula gave 0.16″ as the answer for the orifice diameter. Then I removed the orifice, measured it, and found it was precisely .16″. Naturally, since then, I have had a very high regard for Napier's formula.

Relocating Equipment Increases Capacity

IT IS IMPORTANT to analyze carefully the conditions for which drainage equipment may be required, otherwise troubles may result which could have been avoided by proper analysis prior to selection of the equipment. As pointed out by the Cochrane Corporation recently the important facts to consider in selection of the proper size of equipment are:

1. The inlet pressure and, infrequently, the back pressure on the discharge side.
2. Weight of condensate to be handled per hour.
3. Water temperature relation to steam temperature.
4. Uniformity of pressure.
5. Uniformity of discharge.
6. Capacity of discharge pipe.

The pressure which influences the rating of condensate drainage equipment is the effective pressure under which the unit will operate. This is the actual pressure at the inlet side. In some cases the back pressure will be of influence, but need not be considered in the usual application.

When the pressure varies materially, consideration should be given to the reduced rating of the drainage equipment at the lesser pressure, so as to avoid possible trouble from failure to discharge the desired amount of condensate.

The unit also should be selected with sufficient capacity to care for peak load conditions, otherwise the equipment drained may become flooded. The average rate of condensate discharge may be 1000 lb./hr., but if peaks of 4000 lb./hr. are reached, the condensate removal unit should be selected to care for the larger flow, particularly if storage of condensate ahead of the unit is impractical under the conditions involved.

The effect of condensate temperature upon discharge capacity is a point which has confused users of drainage equipment. The temperature of condensate in relation to its pressure has a significant effect on the discharge capacity of any drainage unit. The capacity is greatest when discharging cold water, but as the

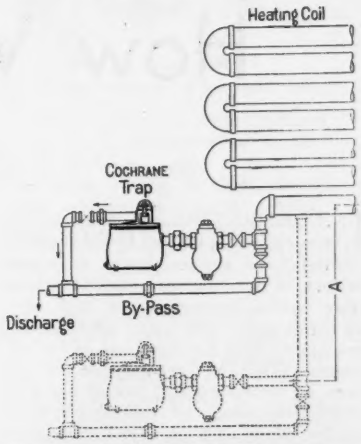


Diagram showing proper location of trap

temperature approaches that of steam at the given pressure, the capacity becomes correspondingly less.

In selecting the proper size of drainage equipment, it is always most conservative to assume that the condensate is at steam temperature, for then the actual existence of a temperature depression (degrees of condensate temperature below that of saturated steam) will provide greater capacity than actually calculated, hence a factor of safety is provided to insure satisfactory operation under adverse conditions.

On the other hand, if the prevailing conditions of installation are such that a temperature depression is known to exist, it is safe to select the proper size of unit on the basis of the depressed temperature.

For instance, in the diagram above, where a Cochrane Trap is shown to be draining a heating coil, installation of the trap directly below the lowest level of the coil will cause condensate to enter the trap at a temperature close to that of saturated steam. Assume, however, that the trap is installed at distance "A" below the lowest level of the coil, with distance "A" equal to 50 feet, and under an inlet pressure of 100 lb. gage. At this pressure the saturated steam temperature is 338° F. but the 50-ft. leg added by lowering the trap increases the static pressure at the trap by approximately 20 lb., or to 120 lb. At this pressure the temperature of 338° is 12° below that of saturated steam, hence the lower position provides approximately 50 per cent greater capacity with the same trap.

As announced in the July issue, under this heading, each month we offer prizes to those persons sending in the best solutions to a specific problem, a new problem being presented each month. Two prizes are offered; a first prize of $15.00 in cash and a second prize of five power plant handbooks. Solutions must be mailed to reach the editorial office of Power Plant Engineering before the 25th of the publication month of the issue in which the problem appears. Manuscripts must not be longer than 1000 words.

How Would You Do It?

IN COMMENTING last month on the seeming lack of interest in our Problem Contest it now appears that we were premature in forming an opinion because since writing those lines we have been all but swamped with letters offering suggestions to help our hero out of his dilemma. While we cannot speak for our hero, we were very well pleased not only by the large number of replies but by their quality. Many of them were excellent, so excellent in fact that we found it difficult to decide which was best.

After much deliberation, however, we have awarded the first prize of fifteen dollars to Max W. Benjamin of the Detroit Edison Co. for his letter discussing Problem No. 1. Readers will recognize Mr. Benjamin as the author of the series of articles on Delray Station appearing currently in POWER PLANT ENGINEERING.

In awarding first place to Mr. Benjamin our decision was based largely upon the comprehensive way in which he analyzes the various aspects of the problem as a whole. As everybody who attempted to solve the problem will agree, there was much left unsaid in the statement of the problem and any accurate solution of it demanded a number of assumptions. Indeed the problem is considerably more involved than we anticipated and we can frankly say that we have learned a great deal more about the theory of extraction than we knew before we studied these letters.

As to the actual conclusions reached it may seem strange that one of the second prizes, for we found it necessary to make a duplicate second prize award, was awarded to a contestant who reached quite the opposite conclusion from that arrived at by Mr. Benjamin. Whereas Mr. Benjamin claims that the amount of steam extracted will not be reduced as a consequence of changing the springs, Julius Brodsky of Rochester, N. Y., one of the winners of the second prize shows that the amount of steam extracted will be reduced.

If this appears inconsistent on our part we wish to state with entire frankness that we are not prepared to say who is right. It is quite possible that both views may be right since the respective contestants discuss the problem from different angles. Indeed, Gibson T. Hutcheson, the winner of the duplicate second prize award, analyzes the problem in still a different way though his concolusins are similar to Mr. Benjamin's.

All this, no doubt must be extremely confusing to our hero who after all wants a definite answer but if it teaches him nothing else, it should teach him that engineering is an exact science only so long as all the facts regarding a problem are known and considered. Our hero has only himself to blame and he should have been much more thorough in presenting his problem. He should have specified whether the turbine was operating, condensing or non-condensing, whether the electrical load had to be maintained constant or whether it could be reduced, what the back pressure on the turbine was if it operates non-condensing. Many other data could have been presented, all of which would have aided in bringing about a more concrete and practicable solution.

Meagerly stated as the problem was, it was inevitable that there be a wide divergence of opinion among the various replies sent in. To a certain extent this was intended but it is probably asking too much to expect a discussion of so involved a problem in a limited space and hereafter we shall see to it that our hero is more concise in stating his problems. This, however, is a common shortcoming.

Here are the prize winning letters:

FIRST PRIZE AWARD

PROBLEM I

By Max W. Benjamin

If the turbine in Problem I is a non-condensing machine exhausting to process, our puzzled hero would be disappointed and perhaps still puzzled after changing the springs in the non-return valves. On the other hand, if the turbine operates condensing and at the same time bleeds steam to process, some improvement would result from changing the valve springs. In neither case would the amount of steam extracted be reduced.

Now, only dictators and experts can make statements like that and have them stick. Because I am neither, and because I want to help our hero steer a true course, it is necessary to give a little explanation along with these answers. Since the problem does not state which type of turbine is used, both will be discussed. This procedure is sure, of course, to cover the actual case and at the same time gives you twice as much for your money. An explanation for the non-condensing machine is the simpler of the two and will be given first.

To begin with, if the process pressure is increased more steam will be condensed. In fact the only way the process pressure can be increased is to crowd heat into the process faster than the process can absorb it at the existing working pressure. This is an everyday experience in the operation of certain types of building-heating systems. If you want to make the building warmer you increase the rate of firing in the boiler furnace and crowd more heat into the radiators, which is accompanied by an increase in steam pressure and radiator temperature. The same thing is true in the process problem. If the process pressure is to be increased a few pounds the working temperature will be increased and more heat must be crowded into the process equipment.

It is stated that the turbine is operating at the limit of its capacity, which means that the steam-admission valves are wide open. If the steam pressure at the throttle is, say, 100 lb. per sq. in. or more, the exhaust pressure may be changed several pounds above or below the existing value of 25 lb. without affecting the throttle flow in the least. Therefore no more steam can be made available to the process and the process pressure cannot be increased by reducing the drop across the non-return valve. As a matter of fact the theory indicates that

if the 5 lb. springs are replaced with 2-lb. springs the process pressure may actually fall somewhat. This conclusion is arrived at as follows: The pressure at the outlet of the non-return valve is determined by the process load, so the pressure at the turbine exhaust is determined by the process load plus the pressure drop across the non-return valve. If weaker springs are installed the turbine-exhaust pressure will be reduced, which in turn will increase the electrical output of the machine and reduce the *heat content* ("enthalpy" they call it now days) of each pound of exhaust steam. Since the reduction in exhaust pressure would not change the *weight* of steam flowing, it follows that the amount of *heat* supplied to process per unit of time would be reduced. Therefore the process pressure would be reduced also.

The whole problem with the non-condensing machine is to increase the steam flow. This might be done by increasing the net area of the first-stage nozzles, or simply by increasing the steam pressure at the turbine throttle if that could be done within safe limits of the power-plant construction. With an increase in steam flow through the turbine the increase in process pressure (and turbine-exhaust pressure) might not be enough to offset the additional electrical output due to the extra steam flow, and the generator would be overloaded. In this case, the turbine-exhaust pressure would have to be increased still further by installing *heavier* springs in the non-return valve.

The case of the condensing extraction turbine is quite different. With a given throttle flow (in this problem the maximum obtainable) the pressure at the extraction stage is determined by the amount of steam flowing to the condenser. If more steam is extracted there necessarily will be a smaller flow to the condenser, the extraction pressure will be reduced, and there will be a slight reduction in the enthalpy of the extracted steam. There also will be a reduction in electrical output which should not be overlooked when our hero makes his charge for process steam. It is entirely possible that the desired results can be obtained in this set up by changing the non-return valve springs, although a change of just three pounds won't quite do it. For example, if the extraction is increased to the amount needed for a process pressure of 23 lb. per sq. in., the pressure at the extraction stage will drop to something less than its former value of 25 lb. per sq. in., maybe to only 24 lb. per sq. in., leaving only one pound for pressure drop across the non-return valve. Should the magnitude of the process load be too great with respect to the steam flow in the turbine it would then work out that the amount of extraction necessary to produce a process pressure of 23 lb. per sq. in. would reduce the extraction-stage pressure to less than 23 lb. per sq. in. and something other than a change in valve springs would be needed. It would be necessary, as in the case of the non-condensing turbine, to increase the throttle pressure or first-stage nozzle area to get a greater steam flow. The net effect of increased throttle flow and increased bleeding is indeterminate from the data given in the problem. Probably a small increase in condenser pressure would offset any net increase in work done in the turbine and restore the generator output to a normal value.

With this explanation before him there should no longer be any questions in the mind of our plant engineer. If there are, just have him send along a little more data on the turbine and process conditions, for only a complete analysis based on adequate information will show exactly what's what.

SECOND PRIZE AWARD

Problem I

By Julius Brodsky

"Frequently extraction lines connected to one of the stages of a turbine are supplemented with steam from other sources, and as a consequence these lines must be equipped with some form of non-return valve to prevent a reverse flow of steam into the turbine."—P. P. E., Jan. 1, 1918.

There are quite a number of different types and makes of valves suitable for this purpose on the market, and since the performance of different types of valves varies considerably, the selection of any valve should be accompanied by an investigation of its operating characteristics to determine if it meets the requirements of the particular job on which it is to be used.

One type of valve that has been used for this purpose is the multiport spring-loaded valve.

Although the primary function of the multiport valve is to prevent a reverse flow of steam into the turbine, it will at the same time, due to its peculiar construction, act as a regulating valve, causing a reduction in pressure proportional to the amount of steam flowing through it, and under certain conditions this pressure "regulation" may prove objectionable.

Any valve may be considered as an adjustable orifice, the maximum opening

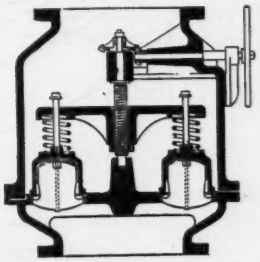


Fig. 1. Cross section of a multiport valve

being attained when the valve is lifted from its seat a distance equal to one-fourth its diameter.

"For steam flowing through an orifice from a higher to a lower pressure where the lower pressure is greater than 58 per cent of the higher, the flow per minute can be calculated from the formula:

$$W = 1.9\ A\ K\ \sqrt{(P-d)d}$$

Where W = the weight of steam discharged in pounds per minute
A = area of orifice in square inches
P = absolute initial pressure in pounds per square inch
d = difference in pressure between the two sides p.s.i.
K = a constant = 0.93 for a short pipe and 0.63 for a hole in a thin plate or a safety valve."

Harding and Willard.

Problem No. 3

This month our hero is confronted with a simple, yet rather peculiar problem. Several new air compressors have been installed recently and since city water is expensive, he has been thinking about utilizing an old deep well on the premises as a possible source of cooling water supply for these compressors. This old well was used years ago but owing to its fluctuating level was abandoned and the deep well pump sold.

Now, however, our hero feels that this well might be able to satisfy the water requirements of the compressors and has been contemplating the installation of a new deep well pump. Before doing this, however, he would like to know just how the water level in the well varies from day to day and has been wondering how he can measure the water level without too much trouble. He would like daily measurements, if not oftener.

He has had various float arrangements in mind, but all of them involve difficulties, since the well is over 100 ft. deep.

The well is located in a small pump house about 20 feet away from the engine room.

Can you offer any suggestions or present a practicable scheme to help our hero in obtaining the desired data? How would you do it, if it were your problem?

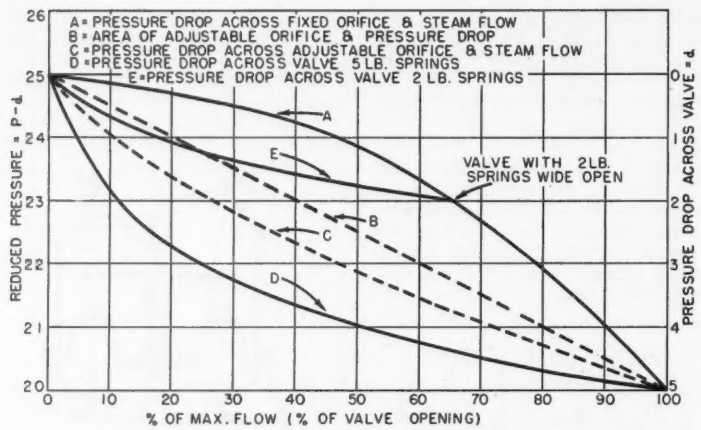

A = PRESSURE DROP ACROSS FIXED ORIFICE & STEAM FLOW
B = AREA OF ADJUSTABLE ORIFICE & PRESSURE DROP
C = PRESSURE DROP ACROSS ADJUSTABLE ORIFICE & STEAM FLOW
D = PRESSURE DROP ACROSS VALVE 5 LB. SPRINGS
E = PRESSURE DROP ACROSS VALVE 2 LB. SPRINGS
VALVE WITH 2LB. SPRINGS WIDE OPEN
REDUCED PRESSURE = P-d
PRESSURE DROP ACROSS VALVE = d
% OF MAX. FLOW (% OF VALVE OPENING)

Fig. 2. Pressure drop across a fixed orifice with variable steamflow

Using the above formula a curve may be plotted showing the pressure drop across a fixed orifice (corresponding to a valve in a wide open position) with variable steam flow, when the initial pressure is 25 lb. psi gage and the maximum flow is reached with a 5 lb. pressure drop or when the reduced pressure drops to 20 lb., the maximum flow at this point is denoted as 100 per cent and the flow at any other point on the curve is expressed as a percentage of this amount.

Since each valve disk is held to its seat by a spring, and the deflection of any spring is proportional to the load applied, then the size of the adjustable orifice (or the height to which the valve will be lifted from its seat) will be proportional to the differential pressure acting on the valve. With a 5-lb. spring in the valve, the valve opening or area of the adjustable orifice will be as shown by the straight line B.

Now since Curve A shows pressure drop across a fixed orifice at various percentages of the maximum flow, and the Line B shows the area of the adjustable orifice for varying differential pressure, then Curve C can be plotted showing flow through an adjustable orifice when the area of the orifice is directly proportional to the differential pressure.

In any actual spring-loaded valve, the force opposing the springs and which is effective in opening the valve is the sum of the static or differential pressure and the velocity pressure. The velocity pressure is a function of the flow through the valve and is proportional to the square of the velocity. Then in any valve of the type under discussion (and this includes all relief, back-pressure and safety valves) the valve opening will not follow the straight Line B, but will be smaller with lower and greater with higher differential pressures. This will result in a modification of Curve C.

Curve D shows the operating characteristics of a spring loaded valve with 5-lb. springs where the initial pressure is 25 lb. psi gage and where the maximum capacity is reached when the valve is fully open with a 5-lb. pressure drop across the valve. Fairly good regulation is obtained between 50 and 100 per cent capacity and if such a valve is used within this range it may prove acceptable as a regulating valve.

Referring to Curve A it will be noted that with a fixed orifice when there is a 2-lb. pressure drop the flow is 65 per cent of that obtained with a 5-lb. drop. From this point on the curve Curve E is drawn showing the operating characteristics when 2-lb. springs are substituted. When the valve opens wide steam will continue to flow but its performance will be that of a fixed orifice as shown in Curve A. The maximum capacity of this valve as a regulating valve using 2-lb. springs would then be only 65 per cent of the same valve when using 5-lb. springs.

Steam supplied to a process system must be at a certain definite pressure with a minimum variation therefrom, and whenever a multiport spring-loaded valve is found in the bleeder line from a turbine to a process system it is evident that this requirement has been met and that the capacity of the valve as a regulating valve is in the range between 50 and 100 per cent of its maximum capacity. Below this range its regulation would be objectionable.

If it was desired to increase the pressure in the bleeder line from 20 to 23 lb., this may be accomplished by increasing the pressure at the turbine bleed point from 25 to 28 lb. and still maintain a 5-lb. pressure drop across the multiport valve at maximum capacity. This increase in extraction pressure would have the effect of decreasing the capacity of the turbine,

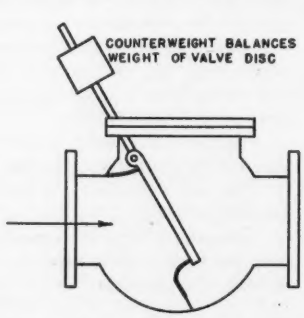


Fig. 3. Free flow reverse current valve

which if it were already loaded to capacity would not be practicable.

In such a case the only reasonable method of obtaining the higher bleed pressure with good regulation would be to replace the multiport valve with a non-return valve of the type shown, which functions solely as a non-return valve without any perceptible pressure drop across the valve, and to lower the extraction pressure at the turbine to 23 lb. and allow the turbine bleeder valve to regulate the pressure in the bleeder line, which is its normal function.

This procedure would have the effect of not only meeting the process requirements as desired but of increasing the turbine capacity. The benefits thus derived would far outweigh the expense of a new valve.

DUPLICATE SECOND PRIZE AWARD

Problem No. I

By Gibson T. Hutchinson

By replacing the 5 lb springs with 2 lb springs, the operator will find a slight increase in the quantity of bleed steam for comparable pressure drops across the non-return valve. This can best be understood by an analysis of the spring characteristics and their effect upon the operation of a non-return valve.

As the pressure in the process line is at present 5 lb. below the bleed pressure, the present springs must maintain a 5 lb. pressure differential across the valve disks, i. e. assuming the valve disks to be 50 sq. in. in area, the spring force is 5 x 50 or 250 lb. This condition can be maintained at only one quantity of bled steam. If the quantity of bled steam is increased, it is necessary to secure more effective area through the valve, or the valve disks must be lifted an additional increment. This would result in an additional compression of the spring holding the valve to its seat, and consequently additional force exerted by the spring. To overcome this additional force, either the pressure on the turbine side must rise slightly above the initial 25 lb., or the pressure on the process side must drop slightly below the initial 20 lb. The latter is most likely, as the quantity of steam used in the process regulates the amount bled.

As the spring scale varies directly as the wire diameter, and inversely as the number and diameter of coils, the space available for the spring in the valve body would determine the size of spring. If we assume the 5-lb. spring to be compressed 3 in., i. e., say 2½ inches initial compression and ½ for valve opening, the spring scale is $\frac{250}{3} = 83\frac{1}{3}$ lb. per in. This would mean that to increase the area through the valve by an additional ¼-in. lift over the initial 5-lb. differential setting, the added spring force required would be $83\frac{1}{3} \times \frac{1}{4}$ or approximately 21 lb. This would require an additional differential across the disks of $\frac{21}{50}$ or 0.4 lb. per sq. in. to get the added capacity.

Now assume the 2-lb. springs are installed in the valve, i. e., springs designed to maintain a 2-lb. differential at the same rate of flow at which the 5-lb. springs maintained a 5-lb. differential. The total spring force required would be $2 \times 50 = 100$ lb. for this condition. As the space limitations are the same as for the 5-lb. springs, the outside coil diameter would be approximately the same, but the wire diameter will be smaller due to the lower load carried by the spring, and the number of permissible coils increased due to the smaller wire diameter. In other words, a weaker spring would be used.

A greater valve opening would of course be required as there is a smaller pressure drop across the disks. This initial valve lift would be $\sqrt{(5 \div 2)} \times$ ½ in. or approximately 0.79 in., since the velocity and, hence area, varies as the square root of the pressure differential, and correcting for the difference in specific volumes at 23 lb. and 20 lb., the valve lift would be approximately $\frac{11.2}{12.1} \times .79 = 0.74$ in. where the specific volumes at 20 lb. and 23 lb. are approximately 12.1 cu. ft. per lb. and 11.2 cu. ft. per lb. respectively. The initial spring compression would be $2.5 + .74 = 3.2$ in. and the scale of this lighter spring would be $\frac{100}{3.2} = 31.2$ lb. per in.

In order to get the same added capacity as was obtained with the 5-lb. springs with ¼ in added lift, an additional lift of $\sqrt{(5 \div 2)} \times .25 = 0.4$ in. will be required, and correcting for the difference in specific volumes, the actual lift would be approximately $\frac{11.2}{12.1} \times .4 =$ 0.37 in order to get the same increment capacity as was obtained with the 5-lb. springs for a ¼ i. additional lift.

To get this added effective area, an additional force of $31.2 \times 0.37 = 11.6$ lb would be required. This would require an added differential across the valve of only $\frac{11.6}{50} = .23$ lb. per sq. in. to get the same increment of capacity as was obtained with 0.4 lb. per sq. in. added differential with the 5-lb. springs.

To summarize, the added capacity with 2-lb. springs results from the facts below:

1. The decrease in flow for the same area varies only as the square root of the pressure drop.
2. The spring force and hence effective area varies as the first power of the pressure differential.
3. The lower specific volume results in smaller area required.

Also the capacity will be slightly increased by the lower friction drop in the valve outlet and in the system due to the lower specific volume.

COMMENTS FROM OTHER CONTESTANTS

In regard to the ultimate result of exchanging the 5-lb. springs with 2-lb. springs as proposed in the problem, opinion seems fairly equally divided. A considerable number of replies indicate that if the pressure in the extraction line is increased by this method, the quantity of steam extracted will be less. Writes William F. Kunz of Philadelphia, "History records ancient alchemists attempting to change base metals into gold; in our present time there are numbers of individuals trying to solve the riddle of perpetual motion. In both cases, however laudable the purpose, results strived for are directly opposed to natural laws and primarily against the inexorable law of compensation. The chief tenet of this law is that we cannot gain one way without losing another; neither can we acquire something for nothing, however much it may appear at times as if we were doing just that. All of which leads up to the fundamentals involved in the problem presented in the July issue of POWER PLANT ENGINEERING. . . By changing the 5-lb. springs to 2-lb. springs the engineer will be reducing the pressure drop across the valve 60 per cent; this in turn reduces velocity and results in a consequent decrease in flow volume." By means of the formula

$$W = d^2 \times C \sqrt{P_1 - P_2 V}$$

used in every day practice for determining the flow across a valve, Mr. Kunz shows that the steam extraction will drop from 63210 lb. per hr. to 41650 lb. a net decrease of 21560 lb.

Julius Mauro, of Pittsburgh, is of a similar opinion. Quoting from his letter, he says "Our hero won't be a hero long unless he gets an idea of the capacities of reduced pressures." By means of a curve derived by interpolation from a handbook chart he shows that with the 2-lb. spring "our hero" will be getting only 75 per cent of the steam per hour that he is getting now.

To compensate for this expected decrease in the amount of steam extracted, several replies, propose the use of a by-pass fitted with a reducing valve around the turbine.

Boyd Abbott of Norristown, Pa., calculates the amount of steam extracted with the weaker springs to be 68.8 per cent of the original. His calculations are quite interesting and his statement of the problem and its solution deserve commendation. His solution follows:

Assume the valve to function in a manner similar to a flow meter orifice and apply the Fundamental Orifice Formula:

$$Q = 1274 \times C \times d^2 \times \sqrt{Hy}$$

where Q = Flow of steam in lb. per hour.
C = Orifice coefficient.
d = Orifice diameter in inches.
H = Differential pressure across orifice in inches Hg.
y = Density of steam in lb. per cu. ft.

Determine the theoretical ratio of orifice diameters or areas to pass the required amount of steam under the two conditions.

Therefore:

d' = Effective orifice diameter when $H' = 10.20$"Hg & $y' = .08405$ @ 20 lb.

d'' = Effective orifice diameter when $H'' = 4.08$"Hg & $y'' = .09079$ @ 23 lb.

(1) $Q = 1274 \times C \times d'^2 \times \sqrt{H'y'}$
(2) $Q = 1274 \times C \times d''^2 \times \sqrt{H''y''}$

Divide (1) by (2)

$$1 = d'^2/d''^2 \times \sqrt{H'y'} / \sqrt{H''y''}$$

and $d''^2 : d'^2 = \sqrt{H'y'} : \sqrt{H''y''}$
$= \sqrt{10.20 \times .08405} : \sqrt{4.08 \times .09079}$

Solving:

$d''^2 : d'^2 = 1.52 : 1$ and $d'' : d' = 1.233 : 1$

From the above solution we see that the installation of 2 lb. springs in the same valve will reduce the amount of steam extracted to 65.8% of the amount passed with the 5 lb. springs.

The desired result could be accomplished if there were enough room in the valve to increase the port opening by 52% and installing 2 lb. springs.

With enough space between the turbine nozzle and the valve for the installation of a by-pass, an additional valve with the capacity to meet the deficiency of steam after the 2 lb. springs are installed could be employed and the same result accomplished.

Horace P. Storer, of Pawtucket, R. I., discusses the probable effect of changing the springs upon the electric generator output. "Since the turbine referred to is operating at the limit of its capacity, any additional steam extracted would reduce by that amoutn, the steam reaching the turbine blading beyond the extraction point . . . the result would be loss of frequency and possibly voltage resulting in lower power factor and increased amperage." Quoting further from Mr. Storer's letter, he says. "Operation at the 23-lb. extraction point could be accomplished under the above conditions by throttling the extracted steam to limit the amount, and could be controlled automatically by an electrical relay, actuated by the frequency, i. e., a device which would operate only at the frequency tended to fall below normal."

Andrew Sheehan of Springfield, Mass., also mentions the effect on the electrical output. "Since the turbine is loaded to capacity, the most serious drawback is the probable reduction of electrical output unless a way can be found to pass more throttle steam. If part of the electrical load is due to motor driven auxiliaries and there are steam driven auxiliaries available, shutting down some of the motor driven equipment would release capacity for the main load. Changing turbine nozzles or raising the initial steam pressure would help if it could be done in this plant."

On the whole, our hero has plenty of advice to digest but unless he actually tries changing the springs he may still remain in doubt as to what actually is going to happen. He, however, is familiar with all the necessary conditions and we hope that with the aid of the excellent suggestions here presented that he will be able to work out this problem to his own satisfaction.

Questions And Answers

Work Schedule for J. M.

IN ANSWER to your request for help on page 542 of POWER PLANT ENGINEERING for August I submit the following schedule which we have found works very satisfactory in our station. Of course this schedule is for a station operating 24 hr. a day and 7 days a week.

Probably the most pleasing part of this schedule from the operator's viewpoint is, one operator completes his round of the schedule each Friday morning at eight a. m. and is relieved of further duty until the following Wednesday afternoon at four p. m.

Hoping this may help you.

ERNEST E. STAFFORD

Portsmouth, N. H.

First Week

Name	Mon	Tue	Wed	Thur	Fri	Sat	Sun
1	12–8	12–8	12–8	12–8	12–8	0	0
2	8–4	8–4	8–4	0	0	12–8	12–8
3	4–12	4–12	0	0	8–4	8–4	8–4
4	0	0	4–12	4–12	4–12	4–12	4–12
5				8–4			

Second Week

2	12–8	12–8	12–8	12–8	12–8	0	0
3	8–4	8–4	8–4	0	0	12–8	12–8
4	4–12	4–12	0	0	8–4	8–4	8–4
1	0	0	4–12	4–12	4–12	4–12	4–12
5				8–4			

Third Week

3	12–8	12–8	12–8	12–8	12–8	0	0
4	8–4	8–4	8–4	0	0	12–8	12–8
1	4–12	4–12	0	0	8–4	8–4	8–4
2	0	0	4–12	4–12	4–12	4–12	4–12
5				8–4			

Fourth Week

4	12–8	12–8	12–8	12–8	12–8	0	0
1	8–4	8–4	8–4	0	0	12–8	12–8
2	4–12	4–12	0	0	8–4	8–4	8–4
3	0	0	4–12	4–12	4–12	4–12	4–12

Repeat first week and so on through the schedule.

Loss Due to Ice

Q. WHAT is the percentage of loss from ½ to up to 3 inches of ice on brine coils in coolers? W. A. W.

Springfield, Ohio.

A. IT IS impossible to answer this question definitely. Ice acts as insulation but its resistance to heat flow cannot be determined accurately. The ice formation will vary from almost clear and very dense ice up to frost, depending on the conditions under which it was formed. It will also depend upon the shape of the coils to a large extent and will be much more effective in reducing heat transmissions with finned coils, due to the fact that the fins or corrugations fill up and thus cut down the effective surface as well as decreasing the heat transmission coefficient.

For a given refrigerating load, the loss which will result comes about through an increased compressor power. The insulation effect makes it necessary to carry lower brine temperature in order to give the same heat transfer with a given amount of surface. A lower brine temperature means a lower evaporating temperaeure, a lower suction pressure and increased compressor input.

In some cases effective defrosting is provided by circulating a small amount of brine over the outside of the coils. of brine over the outside of the coils. of course, absorbed by the brine and it is necessary to make provision for this dilution either by adding more salt or by boiling out the excess water.

Surface Necessary in Brine Cooler

Q. AMONG other refrigerating equipment we have in our plant a double pipe brine cooler in which brine is cooled for making ice. A 15 ton ammonia compressor is installed but difficulty has been experienced in attaining this capacity and I am of the opinion that the cooler is too small. The cooler consists of two banks of coils, 8 pipes high, 12 ft. long. The inner or brine pipe is 2 in. in diameter and the outer pipe 3 in. Can you give me any suggestions? J. THORNTON

Vancouver, B. C.

A. A NUMBER of things may be responsible for your lack of capacity but assuming that the compressor is in good shape, the size of the cooler may be checked by testing the coefficient of heat transfer through the brine pipe. This is measured in B.t.u.'s per square foot of surface per degree of temperature difference per hour.

One ton of refrigeration is equivalent to 288,000 B.t.u. per day or 12,000 B.t.u. per hr. With a capacity of 15 tons the heat transmitted to the brine is $12{,}000 \times 15 = 180{,}000$ B.t.u. per hr. The area of the brine pipe is $2 \times 8 \times 12 \times 3.14 \times 2 \div 12 = 100.48$ sq. ft. The heat transmitted is then $180{,}000 \div 100 = 1800$ B.t.u. per sq. ft.

Assuming now, a temperature difference of 10 deg. between the brine and the ammonia, we find the coefficient to be $1800 \div 10 = 180$ B.t.u. per sq. ft. per deg. per hr.

The coefficient of heat transfer used by manufacturers and designing engineers in designing such coolers varies widely, depending largely upon the temperature difference between the brine and the ammonia and also upon the velocity of flow. The minimum and maximum seems to be about 50 and 150 respectively.

Assuming an average value of say 100 B.t.u. per sq. ft. per deg. per hr., it will be seen that the factor 180 as obtained above is 1.8 times too high or that the surface should be 1.8 times as large as it is. In other words, instead of the 16 tubes which the cooler now contains, there should be 1.8×16 or 29 tubes.

Current Transformers Connected in Series

Q. IS IT good practice to connect the secondaries of current transformers in series. Is it necessary with such connections that the currents in the respective transformers be equal? H. K.

Minneapolis, Minn.

A. WHEN two transformers are connected in series as shown in Fig. 2 the current in all parts of the secondary must be the same, likewise the current in all parts of the primary. If the ratios of the transformers differ the actual current in the secondary will be a compromise

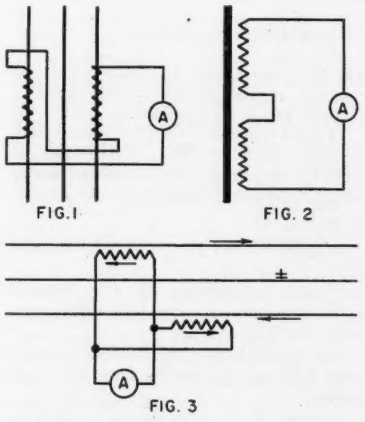


Diagram showing Proper and Improper Transformer connection

between those indicated by the two ratios, and the result will be saturated iron in both transformers and consequently poor ratio and phase angle. The connections shown in Fig. 1 are not correct. If the connection is intended for a three-wire, single phase system, the sum of the currents in the outside wires is wanted and the connection would be as shown in Fig. 3. Where a three phase system is involved, however, the connection shown in Fig. 3 will give a reading proportional to the vector difference of the two currents. For balanced circuits this will be $\sqrt{3}$ times the current in either line.

Calculation of Excess Air

Q. SOMEWHERE I have seen a formula for the calculation of excess air from the CO_2 content of the flue gas. Can you give it to me? O. P.

Chicago, Ill.

A. THE amount of excess air required for combustion can be calculated from the value of CO_2 in the flue gases only if combustion is complete and when the fuel ratio of the fuel is known, that is, the ratio of carbon to hydrogen. The excess air is given by the following formula:

$$\text{Excess air} = \frac{20.9\,R}{CO_2\,(R+3)} - \frac{R+2.37}{R+3}$$

in which CO_2 = the per cent CO_2 by volume in the dry flue gas.

R = the fuel ratio for fuels as follows: Anthracite 50-25; semi-anthracite 25-20; semi-bituminous 20-16; Bituminous 16-12; Lignite 12-9.

Strange Behavior of Synchronous Motor

Q. WE HAVE been confronted by a rather strange behavior of a synchronous motor in our plant which several of us would like to have explained. The motor is a 770 hp. synchronous motor with name plate data as follows: 770 hp., 2200 v., 162.5 amp., 100 per cent p. f., 3 phase, 60 cycles, 200 r.p.m., 56 excit. amp., 250 v. excit. voltage 100 per cent load 24 hr.

This motor pulls 40 amp. with 1 cylinder loaded, 80 amps. 2 cylinders loaded, 120 amp. 3 cylinders loaded and 162.4 amp. with 4 cylinders loaded, it being a 4 cylinder machine the motor drives.

The above values are the readings obtained under normal conditions. Lately, however, we noticed that something is changing these readings at certain times of the day. One cylinder makes the reading go from 60 to 80 amp. Two cylinders raise it to about 110 amp. Three cylinders to 155 amp., but the use of 4 cylinders provides only the normal full load reading of 162 amp. This condition starts about 7:30 a. m. and lets up about 3:35 p. m.

This motor derives its excitation from a motor generator set which also feeds another synchronous motor, about 22 tempering lehrs automatically controlled, and supplies power for a magnetic extractor.

It is claimed that there is no change in the line condition or in the operating condition of the motor generator set.

Any suggestions will be appreciated.

BURTON J. CHAPMAN

Canton, Ohio.

A. FROM a consideration of the problem as you have stated it, it seems almost a foregone conclusion that the trouble lies in the machine which the motor is driving. You do not state what sort of a machine this is but assuming it to be a compressor, it would seem that something tends to increase the load on three of the cylinders during the time specified. Certainly, if the line conditions (voltage and power factor) remain constant as you say, there would be nothing to change the current input to the motor except an increase in load.

The first thing to determine in this case is whether the load itself is changing. If that is found to be normal in each case, then it would be time enough to check the operation of the motor itself.

The value of the exciting current is important in the operation of a synchronous motor and we would advise you to check this accurately. In any synchronous motor, with a given load a definite excitation results in a minimum armature or stator current. This condition corresponds to 100 per cent power factor. At other values of excitation there is more or less lagging or leading wattless, current, the amount depending upon the departure from unity power factor excitation.

Difference of Opinion Makes Horse Racing

If engineering was the exact science it is sometimes said to be, there would be little room for argument or discussion on these pages. A question stated properly and fully would be answered correctly and with finality and there would be nothing more to it. But engineering, applied as it is by human beings is subject to all the frailties and shortcomings of human beings and very few problems or questions that come up in engineering permit of a single, concise answer. So, if you do not agree with some of the answers to these questions, for Pulverized Pete's sake, do not keep your ideas to yourself. Let us know about them and we will see to it that they are told to the world—at least our world of Practical Engineering readers.

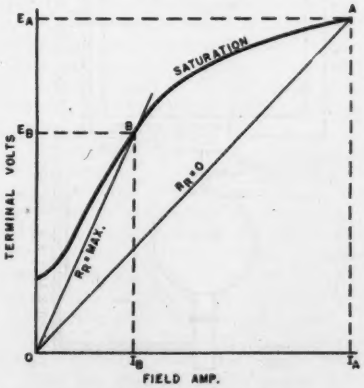
Size of Field Rheostat

Q. HOW CAN I determine the size of field rheostat necessary for a 2 kw. 220 v. 10 amp. shunt wound generator?

Santa Fe, N. M. J. KORTEN

A. IT IS impossible to determine the size of a field rheostat from the data you submit. To calculate the rheostat resistance and capacity, the following data must be available:

1. The saturation curve, or a curve showing terminal volts at normal speed, plotted against field amperes.



Curves for determining size of Field Reostat

2. The amount of voltage regulation desired.

3. The resistance of the field winding.

A typical saturation curve for a shunt wound generator is shown in the accompanying drawing. Assume that the field resistance line corresponding to the zero setting of the rheostat is that marked $R_B = 0$. This line shows the voltage necessary to send various currents through the resistance of the field winding; it is a straight line through the origin with a slope equal to the resistance of the field winding. The intersection of A of this line with the saturation curve determines the maximum terminal voltage obtainable at normal speed, since the voltage necessary to send any current greater than I_A through the field winding could not be generated with that field current. Then assume the E_B is the minimum voltage which it is desired to obtain by means of the field rheostat. The saturation curve shows that a field current I_B is necessary to generate this voltage.

The total resistance of the field current for this condition then is $E \div I_B$ ohms and is equal to the slope of the straight line connecting the origin with point B, marked R_B = Max. in the diagram. The resistance required in the field rheostat is, therefore, given by the difference between this maximum total resistance and the resistance of the field winding. A standard rheostat should be selected whose resistance is equal to or slightly greater than this value. The rheostat should have a continuous current rating at least as great as the field current I_A corresponding to the zero setting of the field rheostat.

Cleaning Ammonia Condenser

Q. WHAT is the best method of cleaning an ammonia condenser? We have a double-pipe ammonia condenser the water tubes of which are very badly scaled. How can these be cleaned? It has been suggested that we fill them with kerosene for a few days. Would this loosen the scale and if so would the kerosene have any harmful effect upon the subsequent operation of the condenser?

Chicago, Ill. T. E. HANSON

A. THE procedure involved in cleaning and removing scale from the water pipes of double-pipe ammonia condensers depends on so many specific conditions not touched upon in your question that it is impossible to give you more than a few general suggestions. The exact composition of the scale itself is perhaps the most important factor and you give us no clue as to what that is.

The first method that comes to mind, of course, is the use of mechanical cleaning tools such as are found on the market. These are similar to those used for removing scale from boiler tubes.

If the scale is so hard that it cannot be removed by running a hand scaling tool through the tubes, it is doubtful whether the kerosene treatment referred to would do any material good insofar as removal of the present deposit is concerned. The virtue of oils is to produce a non-homogeneous "rotten" scale formation rather than to affect the scale after it has formed. For this purpose a heavier oil is more advantageous because it leaves a heavier deposit tending to produce a line of cleavage between the layers of scale deposited before and after the application of the oil.

One method which used to be used in cleaning evaporators might be applied in cleaning a condenser. This is the so-called cracking process in which the tubes are heated by the passage of steam through them and then suddenly admitting cold water. The consequent contraction causes a relative movement between the tubes and the scale and the scale cracks off. If, previous to the formation of the scale, oil had been applied it is possible the scale would crack off more readily than without it

In your case, turning off the cooling water until the water pipes and scale had come to the temperature of the condenser and then suddenly turning the water on again probably would have some effect in loosening the scale, and the periodic use of oil undoubtedly would make the scale more readily removable.

Induction Motor Refuses to Start

Q. ONE OF the drives in our plant required a constant speed motor. The only machine available, however, was a three phase 440 v. six pole wound rotor induction motor, so we adapted it for use as a constant speed machine by operating it with the rotor winding short circuited at the slip ring brush holders. For starting we use a compensator with start and run positions.

This arrangement works satisfactorily and in nine cases out of ten the machine will start its load and come up to speed in a normal manner. There are times, however, when the machine will not start and during the time that this condition exists it seems as though a single phase condition exists or that the rotor is locked magnetically in one position.

At such times, by moving the position of the rotor either clockwise or counterclockwise with or without current on the stator the motor will start its load without trouble. The motor appears in perfect condition, it has been checked for reversed poles and phases.

Can you suggest anything to overcome this difficulty? F. MORAN

Berwyn, Ill.

A. AS YOU suggest, the reason that this motor will not start with the rotor in certain positions is because the rotor is magnetically locked in position. The remedy is to insert external resistances in the rotor circuit during the starting period. Should this be inconvenient you might try short circuiting only two of the rings through their respective brush holders when starting. This method has generally been successful in starting such a motor. Under these conditions the rotor is operating with a single phase winding and will accelerate to one-half of normal speed. It will then be necessary to short the third ring to bring the motor up to normal speed.

The insertion of external resistance in the rotor circuit is, of course, the recommended method of starting wound rotor induction motors. With wound rotor motors of small horsepower rating, however, and a load of small inertia, the method suggested above may prove satisfactory; at least it can be no more severe on the motor than the method you now employ. In the case of present day designs the tendency to lock in position is overcome by skewing the rotor slots.

Through the Air Heater

IN THE August "Practical Engineer" section, the question of what per cent of the total air for combustion passes through the air heater was raised. The air passing through the air heater depends upon two factors: The tightness of the boiler setting, and the tempering air required by the pulverizer.

The infiltration through the setting will vary from about 5 to 20 per cent, depending upon the type and age of the furnace. A small, compact modern unit will have the least leakage, and the larger slag tap and hopper bottomed furnaces will approach the upper limit.

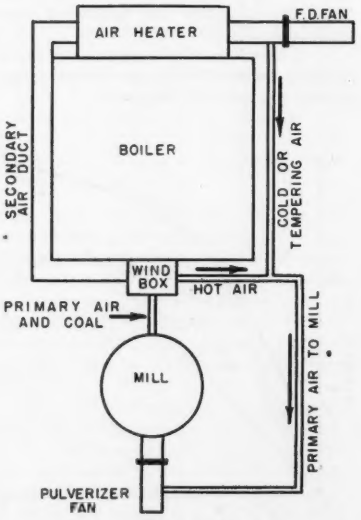


Diagram showing method of tempering air Schematic Diagram of superheated air system

If the pulverizer is of the type that uses preheated air from the air heater to dry the coal in the pulverizer, there will be an additional deduction. The preheated air from the air heater is usually at a temperature too high for evaporating the moisture in the coal without precoking the coal in the burner pipe. This air must be cooled down, or "tempered", by cold air, either directly from the forced draft fan, or from a connection open to the mill room. The schematic diagram shows how this may be done.

The cold air which enters the furnace as primary air without passing through the air heater may be computed as follows:

Let

W_H and T_H = the weight and temperature of the hot secondary air to the mill.

W_C and T_C = the weight and temperature of the cold "tempering" air to the mill.

W_P and T_P = the weight and temperature of the primary air required by the mill.

SH = the specific heat of air at constant pressure.

The total heat contained in the primary air above room temperature must equal the total heat in the preheated air above room temperature; or

$$W_P \times SH \times (T_P - T_C) = W_H \times SH \times (T_H - T_C) + W_C \times SH \times (T_C - T_C).$$

Since $T_C - T_C = 0$, and since the specific heat is the same throughout, this equation simplifies to

$$W_P \times (T_P - T_C) = W_H (T_H - T_C).$$

$$\frac{(T_P - T_C)}{(T_H - T_C)} = \frac{W_H}{W_P}$$

$$W_H + W_C = W_P$$

$$\frac{W_P - W_C}{W_P} = \frac{(T_P - T_C)}{(T_H - T_C)}$$

$$W_C = W_P \times \frac{(T_H - T_P)}{(T_H - T_C)}$$

This is the weight of the primary air which does not pass through the air heater.

G. C. KOHLAR

Long Island City, N. Y.

Should Exhaust Be Run Into Stack?

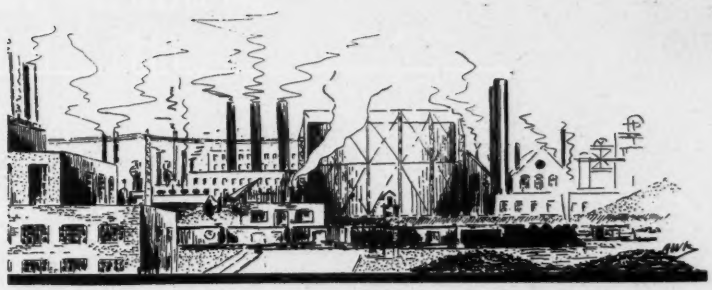
Q. WE HAVE in our plant two steam driven air compressors which exhaust steam into the atmosphere. The opening of the exhaust steam pipe is located twenty-five feet above the ground and five feet from the chimney stack. The stack is constructed of brick and is 110 ft. high.

The problem is: if there were an opening made into the side of the stack and the exhaust steam pipe run into the stack, allowing the steam to exhaust into the stack, would the ensuing results be detrimental or beneficial as regards, draft, chimney mortar and boiler operation?

JAMES A. LICCARDI

Cleveland, Ohio.

LETTERS AND COMMENTS



Feeding Chemicals Into Boiler Feed Line

COMMENTING on the method of "Feeding Chemicals into Boiler Feed Line" in the July issue, may I suggest that in using this method, there is a possible chance of entraining air in the enlarged section of the feed-water line unless provision is made for, and care used in completely filling this section so as to exclude all the air. As is well known, air entering into the boiler by whatever method is often a cause of serious pitting, for wherever the air bubbles attach themselves to the interior of the boiler, chemical action takes place and little blisters are soon formed underneath which a distinct erosive or pitting action can be detected, and if allowed to continue will develop serious trouble. These blisters are often coated in such a manner as to make them look like knobs or crusts of scale formations, but on puncturing them moisture will be found inside and invariably a spongy condition will exist, a removal of which will expose the erosive condition. Simple methods, such as the one described are often practical and inexpensive, but care must be used in its application, to see that no air is trapped in with the feedwater compound and so get carried into the boiler when the feedwater circulation is established. One should never lose sight of the effect of dissolved oxygen in boiler feedwater, and should guard against its introduction as much as possible.

Ansonia, Conn.

WILLIAM T. ESTLICK

Coal vs. Petroleum

WE HAVE recently completed an experiment with the burning of "Crude Oil Residue," or, petroleum coke, which we purchased from a local refinery.

The coke was burned in a 300 horsepower water tube boiler having a pulverizer feed.

The experiment lasted over a period of three months and the results derived we feel are of considerable interest. When the figures of the cost, consumption and work done are compared with the figures compiled for the same period of time under nearly the same conditions, for coal, which I have listed below, it can readily be seen that the coke is by far the more economical fuel.

COAL

B.t.u. per lb.—13,500

Cost per ton delivered—$4.25

Average tons burned per day—15

Average cu. ft. of air compressed per day—2,355,092

Kw-hrs. used to operate pulverizer motor per day—456

Averaged load demand—9500 lb. per hr.

PETROLEUM COKE

B.t.u. per lb.—19,500

Cost per ton delivered—$3.00.

Average tons burned per day—12

Average cu. ft. air compressed per day—2,554,034

Kw-hr. used per day to operate pulverizer motor—337

Averaged load demand 9500 lb. per hr.

Due to its high B.t.u. content the coke required much more air to secure good combustion, and because of that fact we had to discontinue the use of it. We found it almost impossible to keep it lit when the fire was low, because the extra air needed for combustion cooled the side walls of the furnace.

It is my opinion that in a stoker fired or hand fired boiler the coke will give satisfactory results at a substantial savings.

JAMES A. LICCARDI

Diesel vs. Purchased Power

BECAUSE I READ your magazine with considerable interest, I am drawing your attention to a paragraph on page 471 of the July 1939 issue. I have been in the power plant field for the last 30 yr. in design, construction and operation, and, frankly. I feel that I know something about it. I suppose that you simply extracted certain paragraphs from an article which was apparently titled "Diesel vs. Purchased Power." I am surprised, however, that you would publish an extract of this character.

The statement is made in this extract: "If all items of cost are considered, the savings by using Diesel power is approximately the difference between the cost of the fuel and lubricating oil for the Diesel and the total cost of monthly power. Don't permit the issue to become complicated with discussions of depreciation, maintenance, labor costs, repairs, etc."

My experience has been that in many cases I certainly would have been glad to allow the item of cost of power not to be "complicated" by the above mentioned factors, but I have never been able yet to find a formula which would eliminate them. They seem to be part of the cost of power.

In addition to the above, the gentleman who wrote this article entirely overlooks the item of "fixed charges." After all, it costs something to build a plant, and the average business man who pays for the plant expects some return on the money he invests in it.

The cost of power would be very much simplified if we could forget all of the items the gentleman mentions, plus fixed charges, as it would place us in a position to produce very cheap power.

The writer wishes to distinctly state that he is not a public utility man and is, in fact, on the opposite side of the fence, but nevertheless he shall always feel that an honest effort should be made to determine the real cost of power, either public utility or individual plant. Most certainly the items cited above plus the "fixed charges" are a legitimate part of the cost of power in any plant.

New York City R. A. LANGWORTHY

Editor's Note:

The statement quoted by Mr. Langworthy is the summary of a paper presented by H. E. Graham of Fairbanks, Morse & Co., before a meeting of the North Carolina Ice Association. The complete title of the paper was "Ice Production Costs of Diesel Power vs. Electric Power." His conclusion was reached only after a very detailed analysis of all the cost factors, including overhead. The paragraph printed on page 471 contained the costs as calculated both considering and without considering overhead. In the first case the difference between Diesel and electric power operation was calculated as 52½ ct. per ton of ice as compared with 60 ct. when the overhead costs were not considered.

Mr. Graham was concerned with a direct comparison of the two methods of operation. He refers only to the "saving" of one method over the other and not to the cost of power as such. Furthermore, the statement quoted is limited by "approximately" with figures given to show the extent of the approximation. We believe that Mr. Graham's analysis is fair and complete for the conditions assumed, although as a representative of a Diesel engine manufacturer he may have assumed conditions which were more favorable to Diesel than to electric purchased power. A more complete abstract of Mr. Graham's paper will appear in an early issue and warrants close study.

PER CENT HEAT LOSS DUE TO FLUE GAS
TEMPERATURE ABOVE ATMOSPHERE
L = PER CENT HEAT LOSS IN FLUE GAS
T2-TQ = TEMPERATURE DIFFERENCE - DEG. F. (FLUE GAS - BOILER ROOM)
H = HEAT VALUE OF FUEL - BTU / LB.
ILLUSTRATIVE PROBLEM:
WG = 42,000
WC = 4,000
H = 11,500
T2-TQ = 450
L = 9.85
WEIGHT OF FLUE GASES / LB. FUEL - LB.
WC = WEIGHT OF FUEL BURNED / HR. - LB.
WG = WEIGHT OF FLUE GASES / HR. - LB.
FORMULA CALCULATED BY CHART:
L = (WG x (T2 - TQ) x Cp x 100) / (WC x H)
L = PER CENT HEAT LOSS DUE TO RISE OF GAS TEMP. ABOVE ATMOSPHERE IN BOILER ROOM
WG = WEIGHT OF FLUE GAS 'O STACK' / HR. - LB.
WC = WEIGHT OF FUEL BURNED / HR. - LB.
T2 = TEMPERATURE OF FLUE GAS - DEG.F
TQ = TEMPERATURE OF BOILER ROOM AIR - DEG.F
Cp = SPECIFIC HEAT OF FLUE GAS AT CONSTANT PRESSURE ASSUMED AS 0.24
H = HEAT VALUE OF FUEL - BTU / LB.

Power Plant Auxiliaries

Cost of construction, cost of operation and reliability of a power plant, depend to a great extent upon the selection and installation of the auxiliary equipment, says well known engineer in outlining modern practice at the Midwest Power Conference

GEO. C. DANIELS,

Mechanical Engineer
The Commonwealth & Southern Corp.
Jackson, Mich.

SELECTION of power plant auxiliaries and their drives will be governed by the size and function of the plant, whether it is isolated or part of an interconnected system, but will also be influenced by the fuel, by the manner in which it burned and by the steam pressure used. They will range from a simple steam driven boiler feed pump, possibly the only auxiliary in a non-condensing engine or turbine plant supplied by hand fired boilers, to the multiplicity of all electric driven auxiliaries in a modern large central station with pulverized fuel fired boilers and turbines operating on the regenerative heat cycle.

Power plant auxiliaries are generally classified into two groups, essential and non-essential, that is those auxiliaries whose continual functioning is necessary for the operation of the plant, and those that are not needed continuously. Essential auxiliaries might also be considered those required to put the plant into operation or operated continuously to prevent damage to the equipment. Thus for an isolated plant such essential auxiliaries would include the boiler feed pump, induced and forced draft fans, and fuel feed. The circulating water and condensate pumps may or may not be essential for starting the plant depending upon whether or not some power can be generated non-condensing.

In a plant that has available an outside source of power the only essential auxiliary would be a boiler feed pump needed to protect the boilers from overheating from the residual heat in the setting or fuel bed in case of a complete plant shutdown. With pulverized fuel fired boilers and completely water cooled, dry bottom furnaces a boiler feed pump is not essential to prevent damage to the boiler in case all auxiliary power is lost. Some modern utility plants have been designed on this basis and do not have a single steam driven auxiliary.

Simplicity Desirable

Reliability of boiler and turbine auxiliaries are essential to continunity of service but reliability is a relative term. In an endeavor to achieve reliability some designers have resorted to complicated designs that may in themselves be a source of unreliability due to a failure of some relatively minor link in the operation. Thus a multiplicity of protective electric relays may defeat their very purpose and in themselves cause added delay in locating and remedying the trouble. Simplicity is a vital ingredient of reliability.

Quick starting is essential for some auxiliaries and desirable for all of them. Rapid location of trouble and ease of emegency repairs or replacement must be kept in mind. Maintenance of auxiliary equipment should be able to be scheduled and the supervision limited to periodic inspection. The apparent unsuitability of some European equipment in American power plants seems to lie in the fact that in this country power plant auxiliaries are not given the close supervision accorded them in European plants. This is not possible with the small operating forces usually maintained in American power plants, nor does it seem necessary in the light of our past experience with auxiliaries designed to operate with the minimum of attention.

Turbine Drives

Since they are the most direct, turbine drives for auxiliaries may appear to be the simplest, and most reliable. For isolated plants some steam driven auxiliaries may be essential for starting up the plant and the plant heat balance may indicate that they are the most economical but the simplicity and reliability of the turbine drive is more apparent than real. With turbine drives, reduction gears are necessary, except for the boiler feed pumps, since the auxiliaries operate at lower speeds than is economical for the turbines. Remote control is not as simple as with motor operated auxiliaries and starting requires more time. Speed governors, steam traps and control valves all have to be serviced and add to the maintenance. Increase in steam pressures and temperatures make the auxiliary drive turbine less attractive from the standpoint of cost and reliability.

Use of electric drives for practically all auxiliaries in central station plants has become almost universal in recent years. This has been due to several factors. The use of the regenerative cycle of feedwater heating from the main turbines eliminates the need of exhaust steam, simplifies the heat balance and the operation because the steam extracted for the feed water heating varies automatically with the load changes. The electric drive is simple, can be started and stopped quickly and conveniently from any control point and is more flexible. The absence of steam piping to the auxiliaries gives more room, simplifies the design and operation and reduce maintenance.

Use of squirred cage motors for practically all station auxiliaries is becoming more pronounced and fewer slip ring motors are being used. Full voltage starting of squirrel cage motors is the accepted practice and pump and fan manufacturers build their equipment accordingly. This practice results in greater simplicity and also a saving in space required. Power consumed by electrical auxiliaries is relatively small and depends largely upon the type of fuel burned and to a lesser extent upon the condensing water conditions and upon the boiler pressure. For gas and oil fired plants the per cent of gross generated power required

by the auxiliaries varies from 3.5 and 4.0 per cent, for stoker fired plants 4.0 to 5.0 per cent and for pulverized fuel plants 5.5 to 6.5 per cent.

In no phase of power plant design has there been more diversity of opinion than over the question of variable speed for driving essential auxiliaries. Variable speed drives save power but can seldom be justified on this basis alone since the first cost is considerably greater. More room is required for the equipment and the greater complication results in increased maintenance and less reliability. Since the reasons for the desirability of variable speed drives varies with type and use of the auxiliaries these will be discussed separately.

Of all of station auxiliaries the induced, and to a lesser extent the forced, draft fans, have the greatest need for variable speed drives. This has been due to the large saving in power that can be effected and also due to the rapid wear on the blades and casing of the induced draft fans if operated constantly at full speed. Variable speed slip ring motors were formerly widely used for this service in spite of the objections of step control which required damper operation below half speed and generally between steps. The control itself also required considerable room and increased the complication.

Two constant speed motors on the fan shaft so selected that the larger motor only operates on the peak load has been used extensively. This is generally more economical than one variable speed slip ring motor and close control with the damper can be maintained. This makes a simple and reliable drive. To be economical, the speed and size of the motors have to be selected carefully. Synchronous speeds have to be selected for the two motors so the designer is very limited in his choice. By careful design it is possible to get a combination that will necessitate operating the larger motor only during peak loads and the smaller motor will require only approximately 40 per cent of the power of the large motor and operate at three-fourths of the speed.

Two speed motors can be obtained but are usually more expensive and one motor is not quite as reliable as two motors. The control of the two motor drive is somewhat complicated by the necessity of switching motors under load and presents some difficulties especially with automatic control.

Hydraulic Coupling

Variable speed hydraulic couplings with squirrel cage motor drives have recently been developed and used which give smooth speed variation from full speed down to approximately 20 per cent speed. The economy of this drive approximates that of the variable speed slip ring motor. It permits cross-the-line starting of the motor without shock and the control is simple and experience thus far indicates that it is reasonably reliable even though another piece of equipment is interposed between the motor and the fan.

Adjustable inlet vane fans have come into very general use for induced and forced draft fans. These fans are driven with a constant speed motor and the quantity of air or draft is controlled by opening or closing the vanes on the fan inlet. This makes a simple and reliable control and where the induced draft fan is located beyond a cinder eliminator or fly ash precipitator the wear on the inlet vanes is negligible. Other and more complicated speed varying equipment has been tried but has not been used extensively enough to warrant further comment here.

Of the various auxiliary drives that of the stoker is usually the most difficult to simplify. The speed control must be very accurate under widely varying torque conditions. A slip ring motor is unsuited because its speed depends upon the torque which is not constant. A d.c. motor drive is probably the most satisfactory for this service. The a.c. brush shifting motor approaches the d.c. motor in performance but is quite complicated and expensive. Mechanical speed changing devices operating with constant speed motors are also used and since the amount of power transmitted is usually not large they can be made to operate with little trouble or maintenance.

Pulverizers

Coal pulverizers usually run at constant speed and normally present no drive problem. Pulverizer feeders may be constant or variable speed depending upon the design and operation of the pulverizers. Variable speed can be obtained by dc. motors usually supplied from small motor generator sets or by mechanical speed varying devices which, due to their small size, are usually entirely satisfactory.

Circulating water pumps are almost universally driven with squirrel cage motors and since the usual practice, in all except very small installations, is to provide two pumps per turbine unit there is sufficient flexibility to take care of the difference between summer and winter and light and heavy load operation without undue power consumption. Variable speed motor drives can only be justified under the most unusual conditions.

Condensate pumps driven at constant speed cause a wide variation in the water in the hot well and at low loads the water may recede into the eye of the impeller causing cavitation and objectionable noise. Occlusion of non-condensable gases in the condensate may also be caused by the excessive lowering of the water in the suction of the hot well pump. To overcome these difficulties the condensate pumps are occasionally driven by variable speed motors but other and possibly simpler means may be employed that permit the use of a squirrel cage motor drive with its simplicity and absence of control. The level in the hot well may be controlled by throttling the discharge or recirculating the condensate, very simple to accomplish automatically, or, the hot well may be deepened to extend below the inlet of the condensate pump. The design of the condensate pump may contribute to the trouble since cavitation is not troublesome with all designs.

All of the other auxiliaries not specifically mentioned above are classed as non-essential, that is, those which may stop for a short time without inconvenience. These auxiliaries are usually driven by squirrel cage motors and offer no problem to the designer other than that they must be adequate for the work required of them, that they can readily be controlled and located conveniently for inspection and repair.

Public Demonstration of G.E.'s New Oil-Less Circuit Breakers

ON AUGUST 12, the General Electric Co. staged an interesting series of tests on their two new oil-less types of circuit breakers before a group of approximately 250 utility, railroad and industrial guests at the Schenectady plant. These tests showed conclusively that new air equipments had been developed capable of serving in applications heretofore limited to oil type breakers.

Two new circuit breakers were demonstrated and tested. One, called the "Magne-blast" because it interrupts its arc magnetically, introduces an entirely new principle in the technique of fast circuit interruption in air. It is designed for use with standard vertical lift-type metal-clad switchgear, thereby realizing all the inherent advantages of this type of switchgear. The Magne-blast breaker is intended for 5000-v. service at interrupting ratings up to 150,000 kv-a.

The air-blast breaker is designed for 15,000-v. service at interrupting ratings up to 1,500,000 kv-a. As its name implies, the air-blast circuit breaker utilizes a blast of air built up under high pressure to interrupt the circuit and break the arc. In addition, the high-pressure air is used to operate the breaker. The stream of air removes the arc products causing the circuit to be interrupted at first current zero after the contacts have been parted.

The testing of the new oil-less breaker equipment took place in the high-voltage testing laboratory of the company's Schenectady works. As they should have been, the actual circuit interrupting tests in themselves were properly uneventful. One official of the company, at the conclusion of the tests, reminded the guests of the old saying that such tests are usually "viewed with disappointment if nothing happens; disgust if something does." He congratulated the switchgear division in being able to "disappoint" its guests.

To demonstrate conclusively that the new type protective equipment could "take it," the interrupting ratings of both breakers were exceeded by as much as 50 per cent in the tests. In spite of this abnormal treatment, however, neither of the breakers showed any signs of damage when disassembled for inspection after being put through their paces.

Tests of the air-blast breaker were conducted first, with seven interruptions performed by the breaker. In the final test the breaker closed 80,000 amp. peak inrush current and interrupted 730,000 kv-a. after six cycles. Duration of the arc was only one-half cycle.

The tests on the magne-blast breaker were equally severe. Again a succession of seven tests were staged that culminated in exceeding the breaker's interrupting rating by going up to 140,000 kv-a. at 4200 v. on the last test. The magne-blast breaker tested was a 5000-v., 100,000 kv-a. unit.

At the conclusion of the tests, officials of the General Electric Company said that they were highly pleased with the demonstration performances of the new oil-less circuit breakers. Several of the company's executives spoke briefly at a dinner in the evening.

M. O. Troy, commercial vice president of the company served informally as toastmaster for the affair and stated that he believed the new oil-less type switchgear would mark an epoch in electrical history.

Fig. 2. Air blast breaker in test vault of high voltage testing laboratory at G-E Schenectady works

E. O. Shreve, vice president in charge of apparatus sales for the company, spoke of the breakers as a "very material advance in the art of protecting electrical circuits," and stated that the company was "very proud of the new equipment."

D. C. Prince, engineer of the switchgear division, emphasized the fact that the breakers are not just in the laboratory or developmental stage, but are actually ready to go into regular service, and cited some of the installations that have already been made of the equipment. Of the air-blast breaker Mr. Prince promised: "This breaker will be made available in ratings up to 3,500,000 kv-a. interrupting capacity at 287,000 v., and this compares with the largest oil-type breakers now in service."

Mr. Prince further described the new air-blast breaker as the first of a line of breakers to be extended to cover the entire breaker field.

Mr. Prince referred to the difficulty of standardization and the inability to handle high voltages as two specific limitations of the type of air circuit breakers used in European countries, and stated that both were overcome by the oil-less breakers introduced by his company.

It was pointed out that both the air-blast breaker and the magne-blast breaker had been designed to permit standard arrangement of buses, current transformers, mechanical interlocks and associated devices. Each breaker is assembled and shipped as a single unit. Size of the new oil-less type breakers is smaller than that of oil breakers in comparable ratings.

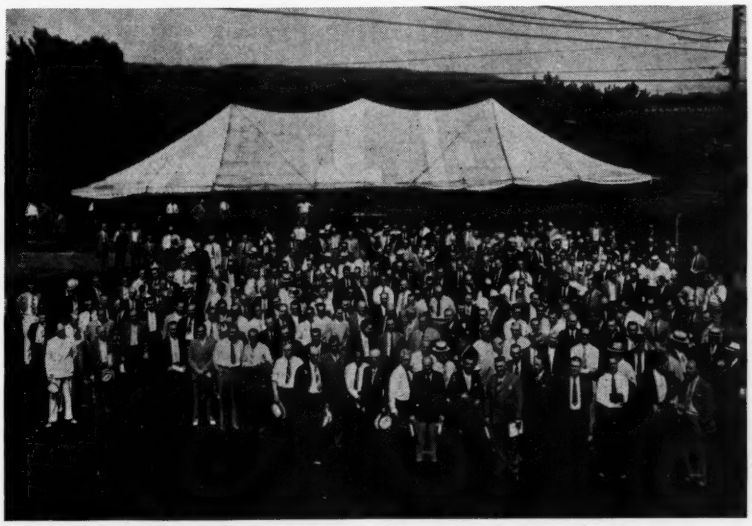


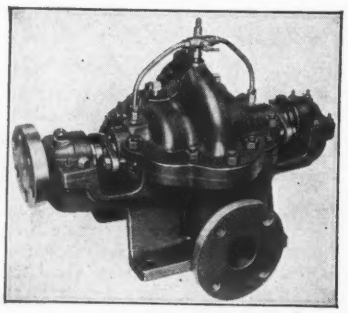
Fig. 1. Utility, railroad, and industrial representatives, and G-E officials in front of the tent erected between test house and the control house

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Single Stage Pumps

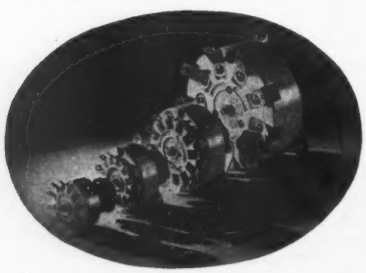
ALLIS-CHALMERS MFG. Co., Milwaukee, Wis., Centrifugal Pump Division, announces the inclusion of ball bearings as standard equipment on nearly all its line of single stage centrifugal pumps. The design is a single row deep groove ball bearing on both ends of the pump in cast-iron adapters arranged for grease lubrication. The designs call for conservative loadings based on carefully computed thrust and radial loads. The



single row type of anti-friction bearings have long been successfully used in the company's motors, which have even much heavier loads than ever experienced in centrifugal pumps. Lock nuts used on the shaft at both ends conveniently hold the ball bearings in place without resorting to any press or shrink fits. The use of an adapter inside the main housing provides a sort of double seal which prevents grease from leaking to the exterior of the pump and at the same time any water which may enter the bearing housing will be thrown off from the shaft before it can enter the adapter.

Power Tap Switches

THREE NEW models in addition to the 40 amp. tap, switch recently announced, now completes the series of new Ohmite all-enclosed high-amperage tap switches. These units extend the convenient application of tap switches to higher currents than ever before practical.



These new tap switches are multipoint, load-break, non-shorting, single-pole, rotary selectors particularly designed for alternating current use. They are remarkably compact and perfectly insulated. The ceramic construction provides ideal insulation. Contacts and mechanism are entirely enclosed and protected. Large diameter silver-to-silver contacts are self-cleaning—require no maintenance. Positive cam-and-roller mechanism provides desirable "slow-break", quick-make action for alternating current — minimizes sparking—increases the life of contacts. The shafts are electrically "dead"—insulated by strong steatite hubs.

These switches meet the switching requirements for any number of applications: switchboards, heater or oven control, arc welders, spot welders, diathermy and x-ray equipment, radio transmitters, voltage regulators, battery chargers, motor control, tapped transformers, electrical machine tools, dryer control, pyrometer circuits, ventilating fan control, meter circuits, etc.

Ohmite Manufacturing Co., 4835 Flournoy St., Chicago, Ill.

Welding Fitting

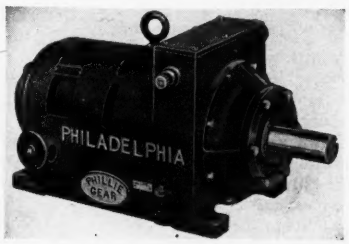
A NEW type of seamless forged steel welding fitting has been announced by Taylor Forge & Pipe Works, Chicago, Ill. The outstanding feature of this welding fitting is the annular lip, which is forged integral with the fitting.

By firmly centering the fitting in the pipe to which it is to be welded, the lip eliminates the need for backing rings, clamps and guides for holding the fitting

in position, and is said to greatly simplify and expedite pipe welding. The ring remains cooler during the welding than the molten weld metal. As a result, the bottom of the "V" appears darker than the sides. This color contrast is said to be an ideal guide to the welder, permitting him to obtain complete penetration without burning through. Like Taylor forge WeldELL, the "Centring" type are full pipe thickness throughout with selective reinforcements in zones where greatest stress occurs. They also have tangents, machine-tool bevels, ends marked in quarter sections, and name, size, and weight rolled into each fitting for quick and easy identification.

Motor Drive

THE NEW Philadelphia PlaneTorque MotoReduceR, supplied for horizontal or vertical drives in all horsepowers and ratios for industrial use, is a motor drive made by Philadelphia Gear Wks., Philadelphia, Pa. The motor is shut off automatically and instantly when the load exceeds a predetermined value. As soon as the excessive load is removed, the unit



is ready to start without resetting. Whenever excessive torque is imposed on the output shaft of the PlaneTorque MotoReduceR, the increased torque required to rotate the planet gears mounted on the output shaft Spider transmits a higher torque to the internal gear which is held in normal position by the lug and heavy spring. When the torque on the internal gear exceeds a predetermined value, the torque spring is compressed. This movement of the lug actuates the switch at the top disconnecting the power.

Valves

ANNOUNCEMENT has been made by McKenna Metals Co., 177 Lloyd Ave., Latrobe, Pa., that pump valves and other valves subject to unusual abrasive or corrosive action are now being made of Kennametal.

Illustrated in Fig. 1-A are several high pressure needle valves, equipped with

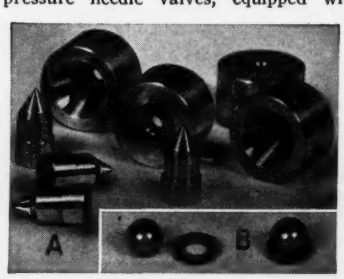


Photo News
Valve values

TITLE REG. U. S. PAT. OFFICE AS TRADE MARK

THE EDWARD VALVE & MFG. CO., INC. • EAST CHICAGO, INDIANA

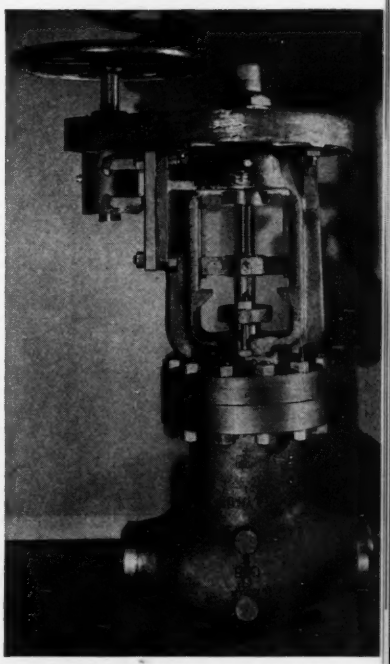
MIGHTY BOILERS SERVED BY EDWARD HAND CONTROL VALVES

SWING TYPE NON-RETURN VALVE FOR EXTRACTION LINES

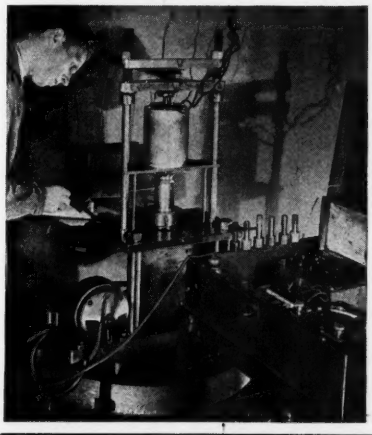
Here is the newest addition to the Edward series of bleeder line non-return valves. This is size 6 in. Other sizes go up to 24 in. In normal use it operates as a plain swing check valve. The bottom cylinder contains a compressed spring, exerting hundreds of pounds pressure, which in case of emergency is released upon loss of turbine oil line pressure, pulling the swing disk to positive closure. Minor refinements have been incorporated in the latest addition to this line, designated in Edward Catalog 11K as Fig. 212. It protects turbines against back flow through a bleeder line. It is made in steel or iron, according to working conditions.

IT'S NEW !

Increased use of Edward globe valves, with parabolic disks for manual throttling regulation, marks recent installations.

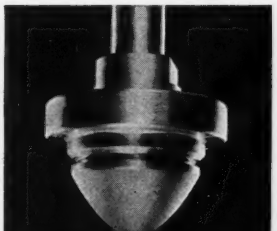


Beginning with feedwater control of an early super-boiler, operating in the 1400 lb range at a steam temperature above 900 F, this type of valve has had occasion to prove its usefulness for water, oil or steam service under widely differing conditions. Shown is a 5 in. 900 lb valve with Stellited disk and seat, built for a southern cotton mill. This bonnet has a pad for possible future installation of motor control. Regulation at present is by handwheel through pinion, gear and EValthrust yoke bushing. Similar valves have been built in various sizes and pressures from 2½ in. to 16 in. and from 200 lb to 1800 lb. In details of construction and internal flow areas they have those characteristics which have been found important in Edward standard globe valves. They demonstrate the rule that it takes a globe valve for throttling service or for tight closure. Your Edward representative has further details.



STUDY ABRASION OF HOT STEELS

Edward laboratory workers have studied for years the problems of friction and galling of valve parts. These tests, conducted with the aid of the equipment at the left, subject rings of steel to high temperatures under reciprocating motion. Loads range from 100 lb psi up to 2000 lb. Chemical and physical properties, hardness, machine finish, prior working—cold or hot—are among the variables related to abrasion tendencies. Recent projects seek to isolate effect of high pressure on surfaces in operating contact.



DISK OF PARABOLIC FORM

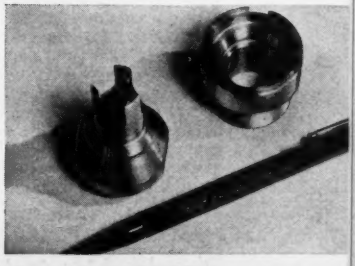
Here is the type of parabolic disk used in the regulating valve above. Through the most useful range of capacity of the valve, the flow area through the seat is proportional to handwheel movement. Seating is on beveled surfaces which separate before the streamlined parabolic plug exerts effective control.

OLD FIG. 2688 DOLLED UP

Perhaps you haven't noticed the rejuvenation of the leader of the Edward forged steel valve lines, Fig. 2688. As the years pass, improvements in material and design have been incorporated without interfering with complete interchangeability of all parts. Conspicuous in this external view of a 2 in. Fig. 2688 are the new streamlined body—with reduction of weight but no impairment of strength or effective wall thickness—the improved packing nut, and the high leverage knobbed handwheel. Over 13,000 sq ft new production space at Edward plant permits simplified and improved quality control.

NOTCHED DISK ALSO USED

For valves of smaller sizes, 2 in. and down, the notched type of triple guided disk shown in the cut has its advantages. The disk lifts well off its seat before full regulation begins through the apertures formed between the seat and the disk guides. The aperture areas vary in proportion to handwheel movement.



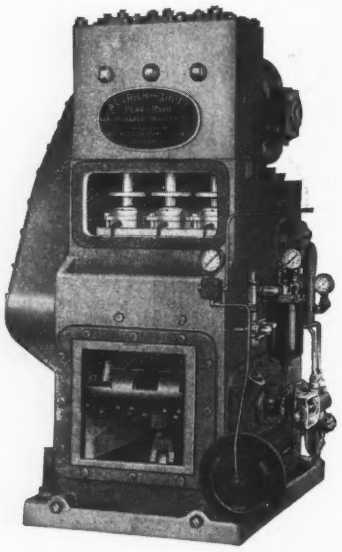
EDWARD Valves
STOP • CHECK • BLOW-OFF • NON-RETURN
FEED-LINE • RELIEF • BLEEDER LINE • ETC.
East Chicago, Indiana

Kennametal needle tip and seat, which were used in experiments involving a tarry fluid containing grit. It was necessary to replace only one valve every one to two weeks.

In tests recently conducted by a large oil well equipment manufacturer, Kennametal balls (see Fig. 1-B) were hammered against seats of Kennametal by a pneumatic hammer, using 300 blows per minute of ram, 25 lb. per sq. in. air pressure and 3/32 in. play between ram and ball and seat. After 105 minutes of hammering, the valves were still serviceable.

Pump

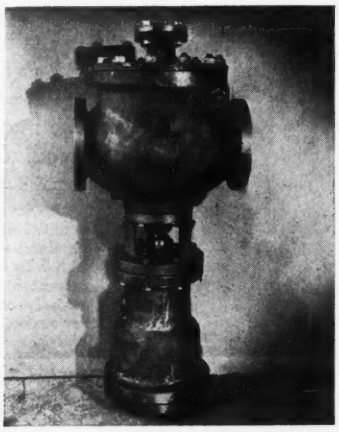
THE ALDRICH PUMP CO., Allentown, Pa., announces the newly developed Aldrich-Groffe "Powr-Savr" Pump which is of the variable-stroke vertical triplex type. This pump affords positive control of delivery without requiring any change in speed to thus utilize constant speed



A.C. motors, or, steam turbines whose economy at fractional loads is considerably improved as compared to variable speed operation as heretofore necessary. Operation of the pump is not confined to high grade lubricating oil as it is designed to handle almost any free flowing liquid at pressures ranging from about 200 up to 15,000—P.S.I. The entire running gear is totally enclosed in an oil-tight frame and all bearing points of the pump proper are positively lubricated by a self-contained pressure oil-circulating system to adapt the pump to severe continuous service with a minimum of attendance and maintenance. Control of the rate of delivery may be accomplished from any desired remote point either manually or automatically using conventional liquid-level regulators; pressure regulators; flow regulators; temperature regulators, etc.

Bleeder Line Valves

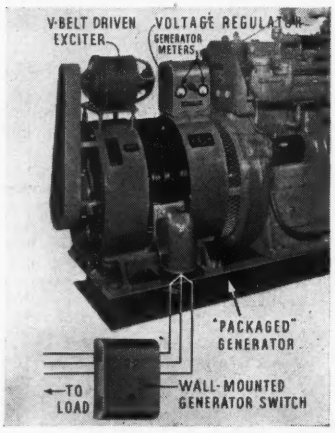
THE EDWARD VALVE & MFG. CO., INC., East Chicago, Ind., announces the Redesigned Bleeder Line Non-Return Valves for use in preventing steam flow back to turbines. Cast iron or cast steel valves of the swing disk type, with oil operated, spring loaded piston on bottom, are available in sizes 6 in. to 24 in. A heavy spring exerting hundreds of pounds of pressure is built into the lower cylinder. Turbine oil pressure from 25 to 45 lb. per sq. in. compresses the spring, but will release it quickly whenever pilot valve drains oil from cylinder. A top and bot-



tom guided stainless steel rod connects piston to disk through a loose link, which allows the disk to swing freely when spring is compressed, but closes disk whenever spring extends. Stuffing box and bypass on top of oil cylinder allows accumulated turbine oil to be safely returned to reservoir. Lantern gland stuffing box on valve permits condensate to be drained away.

"Packaged" A-C Generator

A NOVEL "Packaged" Generator for producing a-c power has been recently developed by Electric Machinery Mfg. Company, Minneapolis, Minnesota. The "packaged" arrangement makes for a compact, simple easily installed, less expensive generator installation. The generator is suitable for direct drive or belted drive by Diesel, gas, or gasoline



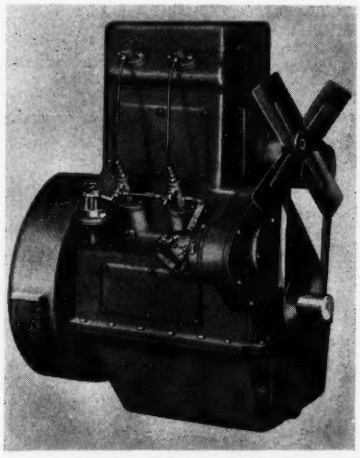
engines and other types of prime movers.

The unit consists of (1) a fabricated, all-steel generator of new, compact, cool-running design, (2) an exciter which is either mounted on and V-belt driven by the generator, or direct-connected to the generator, and (3) a generator-mounted voltage-control cabinet which contains a voltage regulator of new, simple construction, and the generator voltmeter and ammeter. The machine is thus a complete, self-voltage-regulating unit ready to connect to the electric power load.

Because voltage regulator and motors are part of the generator the usual switchboard is not necessary. Leads from the generator can simply be run to the load through a wall-mounted or floor-mounted generator switch. Ordinary a-c motor starters are well suited for smaller, low-voltage generator switches.

Diesel Engine and Generator

THE NEW Hill-Diesel Engine and Generator now in production by the Hill-Diesel Engine Co., Lansing, Mich., is rated at 5 to 7½ kw. The new 2R engine

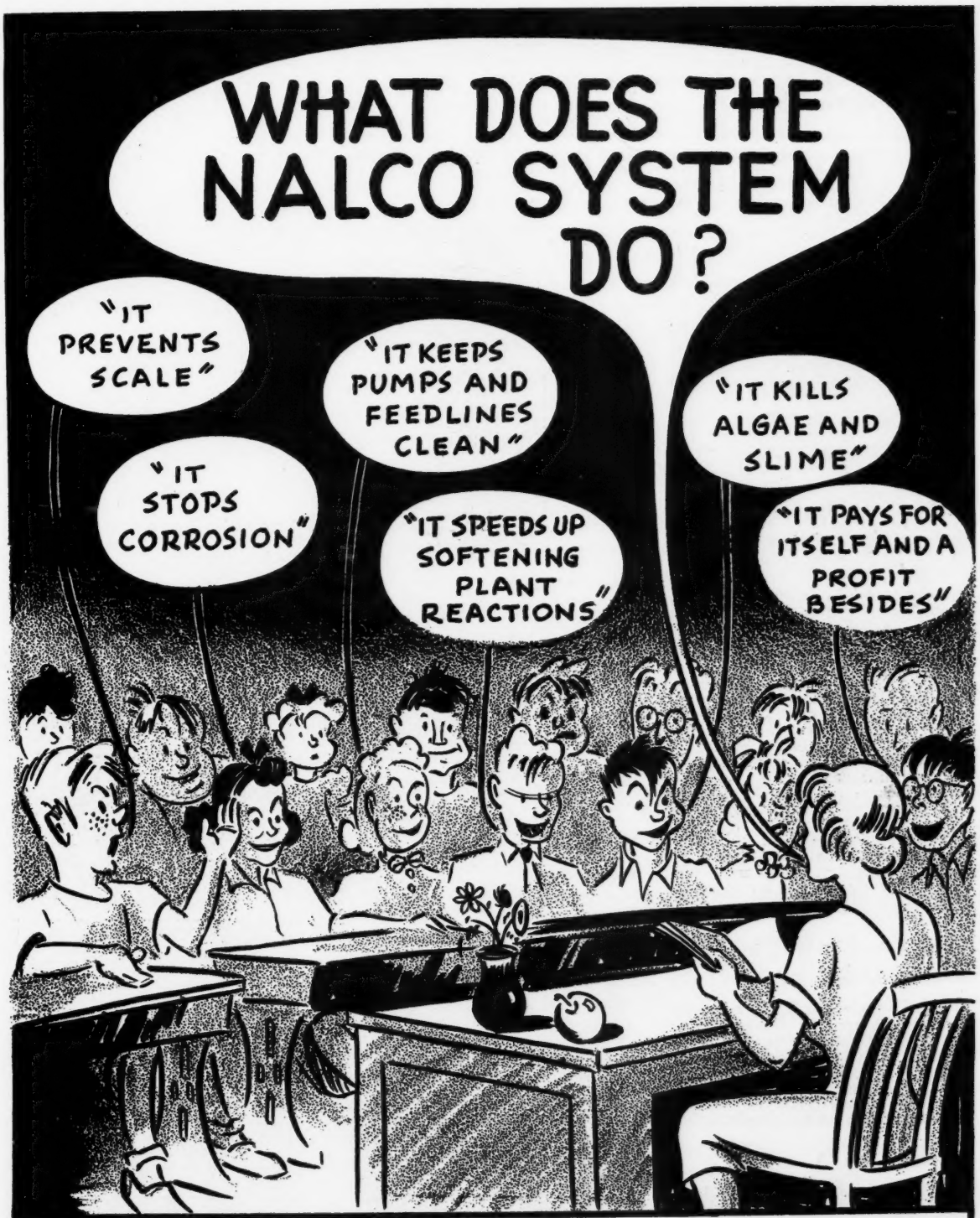


has two 3½ by 5½ in. cylinders, is designed for 1200-1800 r.p.m. operation and has a rated output of 15-20 hp. Starting equipment includes a 12 v. motor, batteries and switch. The net weight of the engine-generator set is 1400 lb.

Circuit Breaker

SQUARE D Co., Detroit, Mich., announces an addition to its line of Multi-breakeRs. By reducing the size and limiting the capacity to 25 a., the new type MO Multi-breakeRs are low in price. The new models now in production are available in single or double pole devices having flush or surface mounting, with or without grounded or insulated neutrals. Capacities are 15, 20 or 25 a. for 115-230 v. a.c. service.

Applications of the new MO Multi-breakeR are many, including electric water heaters, small electric ranges, branch lighting and motor circuits for industrial plants, homes and farms. With


WHAT DOES THE NALCO SYSTEM DO?
"IT PREVENTS SCALE"
"IT KEEPS PUMPS AND FEEDLINES CLEAN"
"IT KILLS ALGAE AND SLIME"
"IT STOPS CORROSION"
"IT SPEEDS UP SOFTENING PLANT REACTIONS"
"IT PAYS FOR ITSELF AND A PROFIT BESIDES"

AND any smart pupil might add: "COMPLETE SERVICE . . . COMPLETE PROTECTION . . . COMPLETE SATISFACTION!" That's what you get when you adopt the Nalco System of Feedwater Treatment. We will be glad to make a survey and report on your plant without obligating you in any way. Write NATIONAL ALUMINATE CORP., 6224 W. 66th Place, Chicago, Ill.

Inquiries other than domestic, except those from U. S. Possessions, Canada and Mexico should be addressed to ALFLOC LTD., Bush House, Aldwych, London, W.C. 2, Eng. Canadian inquiries should be sent to ALUMINATE CHEMICALS LTD., 372 Bay St., Toronto, Ont.

THE NALCO SYSTEM OF FEEDWATER TREATMENT

this grounded neutral the 2-pole device will have extensive use as service entrance equipment for small homes and cottages.

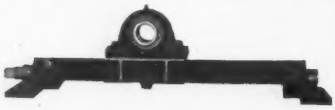
200-Ampere-Welder

HARNISCHFEGER CORP., Milwaukee, Wis., announces its new P&H-Hansen Model WA-200 (square frame) welder which provides extremely simple adaptation for use in parallel hookups. These new square-framed welders, which occupy only 3½ sq. ft. of floor space, give a welding range from 40 to 225 amp. Where a wider range is desired, as is the case in many plants for an occasional job or so, they may be mounted one on

the other and hooked in parallel. When two units are mounted in parallel, such an installation provides two 225-amp. welding services, or one 450-amp. welding service. Thus installed, they may be used singly or in parallel, connected or disconnected at will by means of a paralleling switch mounted on the unit at the bottom. When used in parallel the two units are controlled automatically in one operation by the Multiple Shifter, making possible a continuance of the P&H Hansen single-current control, whereby, automatically, the open circuit and arc voltage are automatically regulated for the proper welding heat.

Flange and Take-Up Bearing Units

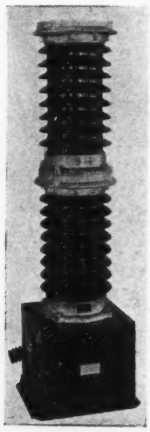
BESIDES their line of permanently sealed Sealmaster Ball Bearing Pillow Blocks, Stephens-Adamson Mfg. Co., Aurora, Ill., are now featuring self-contained Flange and Take-Up Bearing Units. The same advanced seal design used for the Pillow Blocks are built into the new Flange and Take-Up Units.



Sealmasters are self-alining Bearing Units with seals built in as an integral part of the bearing proper, independently of the housing. The Sealmaster Centrifugal Labyrinth Seal effectively seals bearing against all foreign material, and retains lubricant. Misalinment of the shaft cannot interfere with the effectiveness of the seal, for even though bearing is removed from the housing, dirt cannot enter the bearing.

Carrier Current Coupling Capacitors

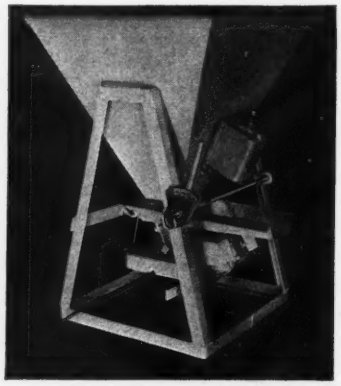
CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J., announce the new large CA Carrier Current Coupling Capacitor. The fog type petticoats give a large creepage distance between terminals. The capacitors are constructed with galvanized malleable iron mounting



flanges so that they may be stacked for series, high voltage connection. New internal mechanical construction affords great tensile strength. The base and top are sealed so as to afford leakproof service. The capacitor sections are designed for low resistance at high frequencies, and very low 60 cycle stress. These individual units are now made up to 46 kv., but may be stacked to operate at any desired voltage.

Vibratory Feeder Machine

DESIGNED primarily as a piece of laboratory equipment and for taking care of real small feeds of material to industrial processing machines, a new, small model FM-0-10 dry feeder machine has just been added to its line of larger capacity vibratory dry feeder machines by the Syntron Company, 494 Lexington Ave., Homer City, Pa.



A 1-cu. ft. hopper supplies material to a vibratory feeder conveyor trough. The rate of flow of material through this feeder trough is regulated by the amplitude of the trough's electro-magnet vibrator which is controlled by means of a rheostat mounted in a separate wall panel controller supplied with each machine. The hopper is kept free flowing by a small electro-magnet vibrator attached to one of its sides that prevents arching over and clogging up of material.

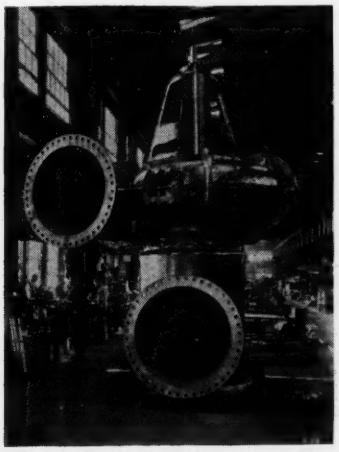
Lamp Changer

A NEW TYPE of safety tool in the form of a suction cup lamp changer has recently been put on the market by the Suction Cup Lamp Changer Co., 826 Delaware St., Scranton, Pa. The lamp changer consists of an especially designed suction cup which is mounted on one end of a pole and provided with a string which releases the grip of the lamp

changer after a new lamp has been put into the socket. The one sized suction cup is designed to grip a large number of different sized lamp bulbs and thus obviates the necessity of having a number of different sized lamp changers. The standard lamp changer as manufactured is equipped with a four foot wooden pole. The company is in a position to furnish an extension packet by the use of which the standard four foot lamp changer can be attached to any length of extension pole.

Flood Control in New England

FOUR HUNDRED MILLION gallons per day is the capacity of 11 Warren pumps furnished for the Springfield, Mass., flood Control Project. The accompanving photograph is a shop view of a 48-in.



unit, one of two of the same size installed at the Phelps Avenue Station in Springfield. Each of these pumps has a capacity of 75,000,000 g.p.d. or 52,000 g.p.m. In addition to these there are seven 30-in. pumps and two 20-in. pumps.

THE ORIGINAL clip type valve with drain channels and bronze bonnet-thread-bushing . . . . . .

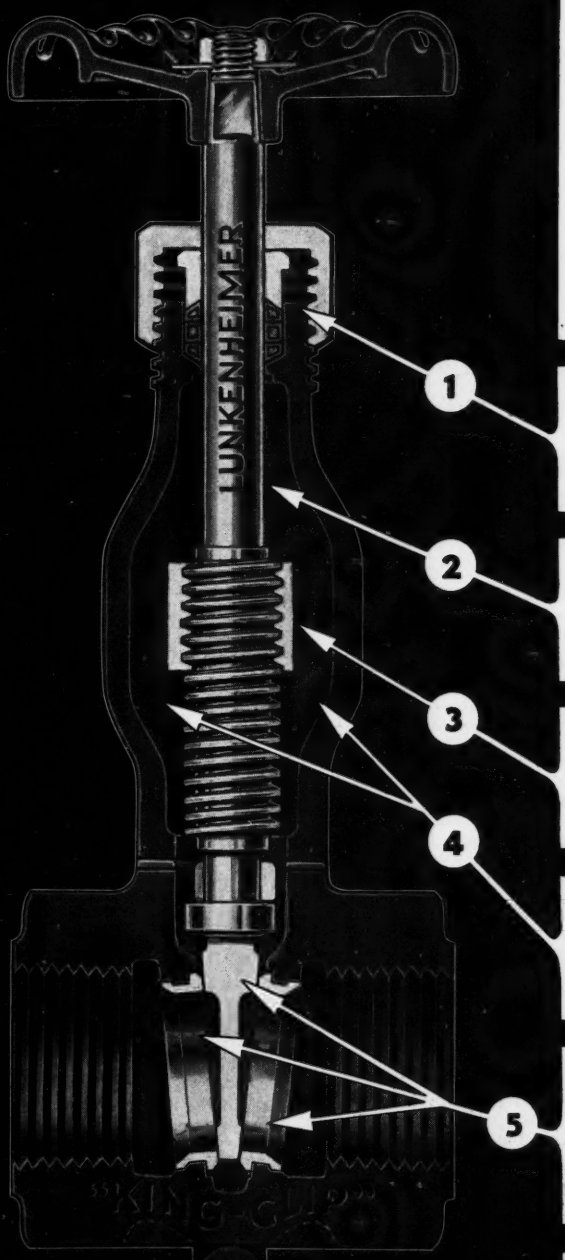


Fig. 1640

LUNKENHEIMER
Fig. 1640
"KING-CLIP"

(The King of Clip Valves)

Stuffing Box
Extra strong construction—hexagon head gland.

Bronze Stem
Perfectly aligned—repacking seat above stem threads.

Bronze Bonnet Bushing—
Cast in. Non-corrodible contact for stem.

Drain Channels
Large and unobstructed—ample size to drain bonnet. Will not clog.

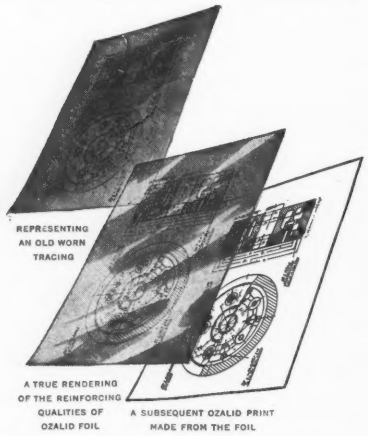
Bronze Disc and Rolled in Bronze Seat Rings
Bronze to bronze contacts prevent corrosion.

ESTABLISHED 1862
THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO
BOSTON PHILADELPHIA
EXPORT DEPT. 318-322 HUDSON ST. NEW YORK

CARRIED IN STOCK BY LUNKENHEIMER DISTRIBUTORS

Light Sensitive Foil

THE OZALID CORP., 354 Fourth Ave., New York, N. Y. The Ozalid foil developed to give the dry developing process all the flexibility of the wet process using negatives and dark rooms. The new foil can be used as a substitute for the original drawing in cases where more than


REPRESENTING AN OLD WORN TRACING
A TRUE RENDERING OF THE REINFORCING QUALITIES OF OZALID FOIL
A SUBSEQUENT OZALID PRINT MADE FROM THE FOIL

one original is needed; to provide an extra fast printing substitute for slow printing originals; to reclaim unserviceable old worn tracings; to superimpose several partial prints so as to obtain a composite print. The foil is supplied in clear, catalog No. 4850 and matted, catalog No. 4975. The latter has a roughened surface which will take ink or pencil lines or erasures in the printed lines can be made with a corrector fluid.

Wire Wound Resistor

WARD LEONARD ELECTRIC CO., Mount Vernon, N. Y., announces a new vitreous enameled wire wound resistor. According to a statement by the company, more than 10 years of intensive research has been spent in development work on refractories, wire processing and enamels. This produced a crazeless enamel structure that withstands humidity, moisture, immersion and numerous other specified tests. The use of New Vitrohm by which the new resistor is known has not necessitated any change in price.

Small Welder

A NEW small arc welding machine, designed especially for use by garages, blacksmith shops, job welding shops, contractors, machine shops, etc., is announced by The Lincoln Electric Co., Cleveland, Ohio. The new machine makes it possible for such concerns to minimize first costs in equipping for arc welding. This new welder, known as the Shield-Arc Junior, has been built for use in conjunction with an engine or electric motor drive and is rated at 200 and its current range, welding duty, 30-v. arc, is 60 to 250 amp. The machine is 29⅝ in. long over pulley, 18 in. high with a base 15½ in. x 19⅝ in. The net weight is 320 lb.

Aluminum Paint

THE SKYBRYTE CO., Cleveland, Ohio, announces a new ready-mixed aluminum paint "Fence-Bond", specially formulated for painting rusted chain link fence without removing the rust. The base oils are of the penetrating type which creep into all joints and contact points, sealing the rust against further corrosive action. The pigment is Alcoa Albron Paste mixed at the factory under controlled conditions. This is said to insure better dispersion of the metal particles and result in a brilliant silvery durable finish.

Fluorescent Lighting Unit

A COMPLETE Fluorescent Lighting Unit for industrial and commercial users has been announced by the Hygrade Sylvania Corporation, Salem, Mass. This unit, called the Hygrade HF-100, is sold complete with two standard HYGRADE 40 watt, 48 inch Fluorescent Lamps, ready to hang up and plug in any standard 60 cycle A.C. socket. Two different types of units are available, one for operation on 115 volts, the other on 230 volts. Among the many advantages of this new unit is the fact that it is corrected for power factor, stroboscopic effect is practically eliminated and it is easy to install.

The Hygrade HF-100 has an overall length of 57 in., overall width of 9 in. and overall height of 7 in. This complete unit is extremely efficient, providing several times the light, with only one-quarter the radiant heat and one-half the total heat of incandescent light sources.

Iron Cocks

A NEW line of asbestos groove-packed iron cocks has been announced by the Reading-Pratt & Cady Division of the American Chain & Cable Co., Inc., Bridgeport, Conn. This new type has the usual gland to hold the plug in position and an additional gland to compress the top packing. Pressure on the plug and packing can be controlled separately. This new design results in a 50 per cent reduction in the effort required to operate the cock and there is less wear on the moving parts. Alemite lubrication is provided through a groove between the top of the plug and the top gland. R-P&C Dual Gland Cocks are made in sizes from 1½ in. to 6 in. for 125 lb. and 250 lb. steam pressures. For corrosive or high temperature services they can be supplied made from Ni-Resist (nickel-chrome) iron.

News from the Field

D. W. HAERING & Co., Chicago, Ill., has moved its offices to the plant at 2308 S. Winchester Ave., where adequate space to accommodate an increased office and executive personnel has been provided. The company laboratory will be retained at 3408 W. Monroe St., where the previous office quarters are being altered to provide new and larger library facilities for the research staff. D. W. Haering & Co. was organized in 1931 for the manufacture of glucoside derivatives for scale and corrosion control developed through the research activities of D. W. Haering. Under the new arrangement, D. W. Haering & Co. headquarters in Chicago will be at 2308 S. Winchester Ave., while research and service laboratories will be continued and expanded at 3408 W. Monroe St. Recent additions and changes in company personnel include the appointment of Chas. W. Bourne in charge of the Virginia territory operating from 725 W. Main St., Richmond, Va. R. E. McConighen in charge of the Wisconsin territory operating from 124 W. Brown St., Milwaukee, Wis., and John A. Coleman in charge of the Dallas area operating from 4104 Stanhope Ave., Dallas, Texas.

BLAW-KNOX Co. announces the appointment of Lawrence E. Joseph as executive officer in charge of its Blaw-Knox Division. Mr. Joseph succeeds R. F. McCloskey, Sr., a company vice president, who was placed in charge of the development of new products for the entire corporation.

NEW ENGLAND POWER ASSOCIATION has asked authorization by Federal Power Commission for its subsidiary, the New England Power Co., to acquire generating station and transmission lines of Bellows Falls Hydro-Electric Corp., also the lines of Connecticut River Power Co. in New Hampshire, which connect Bellows Falls Co. system to that of New England Power Co. For the Bellows Falls system the price is to be $12,381,739.66 of which $9,000,000 will be in cash and the balance in common stock at $30 a share or in cash. The Connecticut Co. will be paid $627,747.30 in cash.

BLAW-KNOX Co., Pittsburgh, Pa., announces the appointment of S. J. Horrell as sales manager of the Power Piping Division, with headquarters at the company's home office in Pittsburgh, Pa.

ELMER H. BOOZ, formerly with the Cochrane Corp., Philadelphia, Pa., has joined the staff of The Paul B. Huyette Co., Inc., Philadelphia office as a sales engineer.

THE RESEARCH PRODUCTS CORP., Madison, Wis., had added Richard C. Poucher to its sales staff. He will take charge of the sales engineering problems for the Air Filter Division of the Research Products Corporation in Ohio, Michigan, Pennsylvania and New York.

P. Y. DANLEY, manager of the air conditioning department of the Westinghouse Electric & Mfg. Co., was elected president of the Air Conditioning Manufacturers' Association at the recent annual meeting in Hot Springs, Va. Other officers are S. E. Lauer, York Ice Machinery Corp., vice president; P. A. McKittrick, Parks-Cramer Co., treasurer; and W. B. Henderson, Washington, D. C., executive vice president.

THE SUMMER MEETING of the National Association of Fan Manufacturers will be held at Manchester, Vermont, on September 14, 15, 16, 1939. At that time consideration will be given to further additions to the established standards and working data now published and distributed by the Association. The response for such information by the architect, engineer and buyers of fan equip-

THERE'S THE RUB!

BEING HUMAN, we might like to do our job sitting down—we might like to study friction from a swivel chair.

But that's out. It takes *field service,* men on the job right with *your* machines, for us to get at the cause and cure of friction.

Take the case of an Oregon gold dredge with sand getting into bearings . . . or the case of a power plant in a mine where lives depended on its running continuously . . . or an Eastern manufacturing plant where output needed to be increased 12 to 30 units per hour.

Shell doesn't believe problems like these and hundreds of others can be solved from a distance. Correct lubrication can't be guesswork.

That is why there are *many* carefully trained Shell engineers, backed by laboratory and refinery experts, on call all the time all over the country. Give them the opportunity to go into your plant, to inspect your equipment. They've saved a lot of dollars for American business by reducing friction—the *right way!*

SHELL

SHELL *INDUSTRIAL* LUBRICANTS

ment has encouraged them to enlarge the scope of this activity.

WILLARD H. COBB, for the past several years general factory manager, mechanical goods plants, United States Rubber Co., has been appointed general manager of the Mechanical Goods and General Products divisions. This position includes supervision of the manufacture of Lastex yarn and rubber thread.

THE FOSTER ENGINEERING CO., of Newark, N. J., has announced the appointment of the Energy Control Co., 55 Brownell Street, New Haven, Connecticut, represented by John A. Larkin, as Sales Agent in the State of Connecticut.

PROFESSOR C. W. Foulk, for years Professor of Chemistry at Ohio State University and well known in engineering circles both here and abroad for his research and many contributions on foaming and priming of boiler waters, has been retained as Consultant on Research by the National Aluminate Corp. He remains on the university staff as Professor Emeritus.

WILLIAM H. DUNN, Comptroller and Assistant Treasurer of Raybestos-Manhattan, Inc., was elected secretary of the Corporation at a meeting of its Board of Directors in New York on July 19, 1939. He succeeds as Secretary the late Morton F. Judd, General Manager of The Raybestos Division of Bridgeport and Stratford, Conn., who died recently.

VLADIMIR KARAPETOFF, professor of electrical engineering in the College of Engineering, Cornell University, retired in June and has been made professor emeritus by the Board of Trustees. Professor Karapetoff joined the Faculty in 1904 as assistant professor of Electrical Engineering, and became professor in 1908. Born in Petrograd, Russia, in 1876, he received the CE at the Imperial Institute of Ways of Communication in 1897 and the MME in 1902, having studied meanwhile at the Polytechnic Institute in Darmstadt, Germany. He came to America in 1902, was with Westinghouse and has been consultant in engineering to General Electric, many engineering firms and utilities, and the United States Government. He is a prolific inventor of electrical devices and musical instruments, a musician, poet, composer, holds a commission as lieutenant-commander in the U. S. Naval Reserve Force, and has written many technical books and articles. On leave of absence since June, 1938, he lives in Leonia, N. J., and will continue as a technical consultant.

CARL LAGER, President of Morris Machine Works, Baldwinsville, N. Y., died at his home in the Adirondacks on July 17. He had been in the employ of Morris Machine Works for nearly 50 yr. Mr. Lager was born in Stockholm, Sweden, in 1869. Upon graduation from a Swedish technical school, and with shop experience in Sweden, he came to the United States in 1887, became a draftsman and foreman for the Allsing Co. of Brooklyn, and afterwards was employed by Henry R. Worthington in Brooklyn, N. Y. Mr. Lager was for 46 yr. a member of the American Society of Mechanical Engineers and was honored by that society with life membership. He was also a member of the Technology Club of Syracuse, N. Y., and the Baldwinsville, (N. Y.) Kiwanis Club. Mr. Lager is survived by a brother, Oscar Lager of Philadelphia and a sister, Mrs. Olga Ohlson of Rochester.

CRANE CO. has been appointed national distributors of the Chiksan Tool Co. In addition to Swing Joints, Crane Co. will also handle barge and dock hose as well as other Chiksan products for industrial use incorporating swing joints.

ROBINS CONVEYING BELT CO. has closed a contract with the Compania Carbonifera y de Fundicion Schwager at Coronel, Chile, for a system of belt conveyors, both underground and surface. The conveyors will handle an ultimate capacity of 300 long tons per hour of 14 in. maximum, dry run-of-mine coal from an undersea mine to a preparation plant. The system consists of eight 36 in. wide belt conveyors, approximating a distance of 2.25 miles. Several of these belt conveyors are exceptionally long. Conveyors Nos. 1 and 2 from the rotary car tippler to the foot of the inclined underground drift are 4300 ft. and 970 ft. long respectively. A series of five belt conveyors then conveys the coal to the mouth of the mine, a distance of about one mile. The surface conveyor from the mine mouth to the preparation plant is approximately 1550 ft. long.

ASSOCIATION of Iron and Steel Engineers will meet in Wm. Penn Hotel, Pittsburgh, Pa., Sept. 26-29. Technical sessions will include 25 papers on steel plant practice; an exposition of steel plant equipment will cover 20,000 sq. ft. of floor space; and visitors will inspect Irvin Works and Edgar Thomson Works of Carnegie-Illinois Steel Corp.

THE NATIONAL ALUMINATE CORP. announces the appointment of Robert Van Grundy to replace J. L. Hickman as service engineer in Texas. Joe E. Davis has been appointed service engineer as an addition to the staff in California.

EDWIN LUNDGREN has recently been appointed vice president in charge of sales of Controlled Steam Generators, Inc., 330 W. 42nd St., New York City.

ALLIS-CHALMERS MFG. CO.'s district office at Chattanooga, Tennessee, of which D. S. Kerr is manager, has been moved and is now located in the Chattanooga Bank Building, 737 Market Street. A new branch office has been established in the U. S. Trust Bldg. at Louisville, Kentucky.

A new branch office has been established at LaPorte, Indiana. B. L. Margeson, formerly in charge of the company's Rockford, Illinois office, will be in charge. J. J. Breutzman, formerly at their Chicago office, will succeed Mr. Margeson at Rockford.

A. B. Frost has been appointed branch manager at their New Haven, Connecticut office to succeed E. D. Hill, who resigned due to illness.

ANNOUNCEMENT has been made of the inaugural Fall Meeting of the American Society of Heating and Ventilating Engineers to be held in Atlanta, Ga., on October 30 and 31, 1939, with the Atlanta Chapter of the Society as hosts. It is planned to have three technical sessions, a get-together luncheon, a banquet and dance, and a program of special entertainment for ladies.

General Committee on Arrangements has been appointed consisting of L. F. Kent, General Chairman; C. T. Baker, Vice-Chairman; C. L. Templin, Reception; S. W. Boyd, Registration and Sessions; E. W. Klein, Banquet; T. T. Tucker, Ladies; A. H. Koch, Sports; G. H. Brodnax, Jr., Transportation; M. M. Crout, Publicity; and C. B. Cole, Finance.

V. B. NICKERSON has joined Jenkins Bros. as industrial sales representative and will travel out of the Cleveland office in the interest of Jenkins Valves and Mechanical Rubber Goods. For the past 26 yr. he has represented Greene-Tweed & Co., traveling the entire continent.

Alfred Dewey Webster

A. D. WEBSTER, Orrville, Ohio, Municipal Utilities Superintendent since January 19, 1925, died July 17, 1939 at the Wooster City Hosptial following an operation for internal injuries suffered in a fall at the local park swimming pool. When the park pool was built five years ago, Mr. Webster was one of its leading advocates, and there is tragic irony in the fact that he is the first fatality to occur at the pool. Mr. Webster was born at Newark Valley, Tioga County, N. Y., and received his degree in electrical engineering and principles of mechanical and hydraulic engineering at the University of Syracuse in 1916, earning top scholastic honors in his class. Following his graduation, Mr. Webster worked for 5½ yr. at the Westinghouse Electric Company plant at Pittsburgh; from 1921 to 1925 was employed by Goodyear Tire and Rubber Company of Akron as chief engineer in charge of motor and control work.

When A. D. Webster came to Orrville at the age of 30 to take the helm of the Municipal Utilities, the village-owned power plant had been operating not quite 9 yr. and was still in debt. His working, thinking and planning have been the major factor in the development of the municipal plant to one of the finest in the nation. The Municipal Utilities plant, including the sewage system which became an adjunct of the department in 1932, had a total valuation of $1,020,936 at the close of 1938, of which the debt-free light plant represented $622,965. Although the population of the village increased only about 12 per cent in the past decade, the close of 1938 saw 55 per cent more electric meters active on municipal lines than when Mr. Webster assumed management in 1925. The amount of electricity sold has been tripled in the period of his superintendency, and the average price paid for all electricity per unit has dropped to less than half of what it was in 1924. He capably managed Orrville Municipal Utilities' four departments—Electric, Water, Sewer, and Ice.

Mr. Webster is survived by his widow and four children.

Robert Henry Thurston Centennial Celebration

AT ITHACA, N. Y., Cornell University will hold a centennial celebration of the birth of Dr. R. H. Thurston on Oct. 25, with delegates from technical societies and engineering colleges. The work of Dr. Thurston in the U. S. Navy and as a pioneer in engineering education at Stevens Institute and Cornell University will be summarized by Dr. J. P. Adams of Brown University, Admiral Wilson Brown of U. S. Naval Academy, Dr. H. N. Davis of Stevens Institute, Dr. W. F. Durand of Leland Stanford University and Dean S. C. Hollister of Cornell University. Dr. Thurston's publications and laboratory apparatus that he designed will be on exhibition.

Prevent steam contamination – the DEARBORN WAY

Experimental Boiler in the Dearborn Laboratories

In this miniature high pressure boiler, Dearborn research engineers can duplicate conditions encountered in large power boilers. Thus, by constantly experimenting with new methods, Dearborn is able to offer the most advanced scientific treatment for the prevention of scale, corrosion, and steam contamination.

Every engineer knows that steam contamination in his plant means eroded and encrusted turbine blades, fouled superheater tubes, clogged up valves, scored cylinder walls, and other crippled equipment. You can prevent these troubles in your plant with Dearborn Treatment and a systematic blowdown schedule based on Dearborn recommendations.

Dearborn Treatment is also balanced to give full protection against scale and corrosion. It not only prevents new scale from forming, but gradually disintegrates any scale already present, while the boilers continue in service.

Dearborn engineers will make a thorough analysis of your plant, furnish a treatment balanced to fit your individual needs, advise you on blowdown, and check up frequently to see that you are getting satisfactory boiler operation.

In thousands of plants, large and small, Dearborn Scientific Water Treatment is saving large sums by protecting boilers from scale and corrosion and by preventing undue steam contamination. See your Dearborn representative. Dearborn Chemical Company, Dept. F, 310 S. Michigan Ave., Chicago, Ill.

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EXPORT • NEW YORK • LOS ANGELES • TORONTO and PRINCIPAL CITIES

Illuminating Engineers Meet in San Francisco

FOR THE FIRST time in the history of the organization The Illuminating Engineering Society held its national convention on the West Coast, August 21 to 25. The spectacular illumination at the Golden Gate Exposition and the part played in it by the membership of the Society caused this convention to be called the society's "Exposition Convention." A great part of the program centered on the illumination aspects of the Fair.

The convention permitted the illuminating men to see not only the lighting of the Fair but also the longest stretch of sodium vapor highway illumination in the world—that across the two bay bridges and the Bayshore highway.

Demonstration of Fluorescent lighting at I. E. S. Meeting

Among the notable figures in the lighting world attending the meeting were I. E. S. president, D. W. Atwater of Westinghouse; Samuel G. Hibben of the same company. A. F. Dickerson of General Electric who was responsible for the exterior illumination at the Fair; Matthew Luckiech and Frank Moss, both also of General Electric.

Mr. Dickerson's paper, "Exterior Illumination of the Golden Gate Exposition" explained the technical and engineering details of the Fair lighting. Following his description of the lighting system the members and guests met at Treasure Island on Monday evening, Aug. 21 for dinner at the Yerba Buena Club after which they were taken on a personally conducted tour by Mr. Dickerson and his associates.

The electric supply and distribution system of the exposition were covered by a paper presented by William P. Bear of the Pacific Gas & Electric Co.

The lighting features of the New York World's Fair were presented by papers read by R. C. Engelken of New York, and Samuel Hibben of the Westinghouse Electric & Mfg. Co. at Bloomfield, N. J.

Fluorescent lighting, naturally, was an important subject at the convention since it was at the Golden Gate Exposition that this new form of lighting was first applied on a large scale. European lighting developments were discussed by C. A. Atherton of Geneva, Switzerland and Willard Brown of General Electric who recently made a trip to Europe to study European practice.

Prof. Parry Moor of Massachusetts Institute of Technology as well as members of the faculty of the University of California and the optometrical societies of the San Francisco Bay region participated in the discussion at the technical session.

The convention was held in the Fairmont Hotel on Nob Hill from which the Exposition both day and night could be plainly seen by the visitors. Scattered about the main floor of the Hotel were interesting exhibits showing the progress and work of the Illuminating Engineering Society and its Committees.

In the Tapestry Room there were on display some of the prize-winning drawings which were entered in the 1939 I. E. S.-Beaux-Arts Prize Award Contest, which was the design of a "Hydro Electric Plant". Many of the solutions show a knowledge of the newest light sources, and the various plans represented are indicative of the trends in modern architecture and illumination design as visualized by the architect of the future.

Fire at Valmont

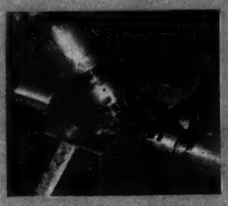
By C. P. O'Brien

LATE in the evening of July 26 a coal pulverizer explosion killed one man and seriously injured another at Valmont station of the Public Service Co. of Colorado. A third man was badly burned while assisting the other two. The force of the explosion ripped out the 90 ft. high, 60 ft. wide, 18 in. east wall of the pulverizer building but caused little damage to other equipment. The mill house was shut down but service was not interrupted for the plant uses the central system and there was sufficient pulverized coal on hand to run several hours.

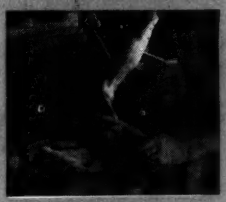
Valmont is located about 4 mi. east of Boulder, Colo., and recently completed a $2,000,000 construction program. The mill which exploded was the sixth and newest in the building and had been in operation about 18 mo. It had been shut down about 15 min. before the accident. The operator noticed a rapid rise in temperature and discharged a quantity of carbon dioxide into the mill before the automatic trip set at 185 deg. F. had a chance to operate. Total damages were around $25,000. John D. Elftman, plant superintendent, said spontaneous combustion caused the explosion.

From Metal To Final Inspection They Must Be Right!

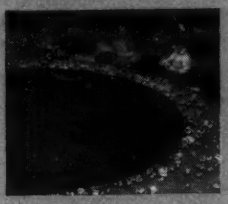
SMOOTH cores for free flow . . . skilled core-makers using finest materials assure smooth inside finish in Grinnell Fittings.



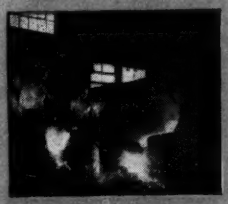
ACCURATE jaws hold the fitting as sharp taps cut the clean threads that mean easy running up and tight joints.



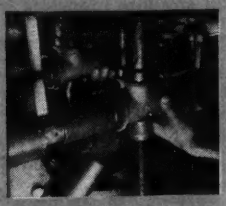
UNIFORM wall thickness and smooth finish are assured by high-grade pattern equipment and careful setting of cores.



RIGID INSPECTIONS check the fittings at three points in their manufacture to maintain the Grinnell Standard.

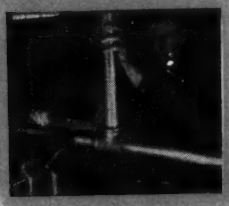


SUPERIOR metal is poured carefully to make these fittings —under direct supervision of the man responsible for each molding floor.

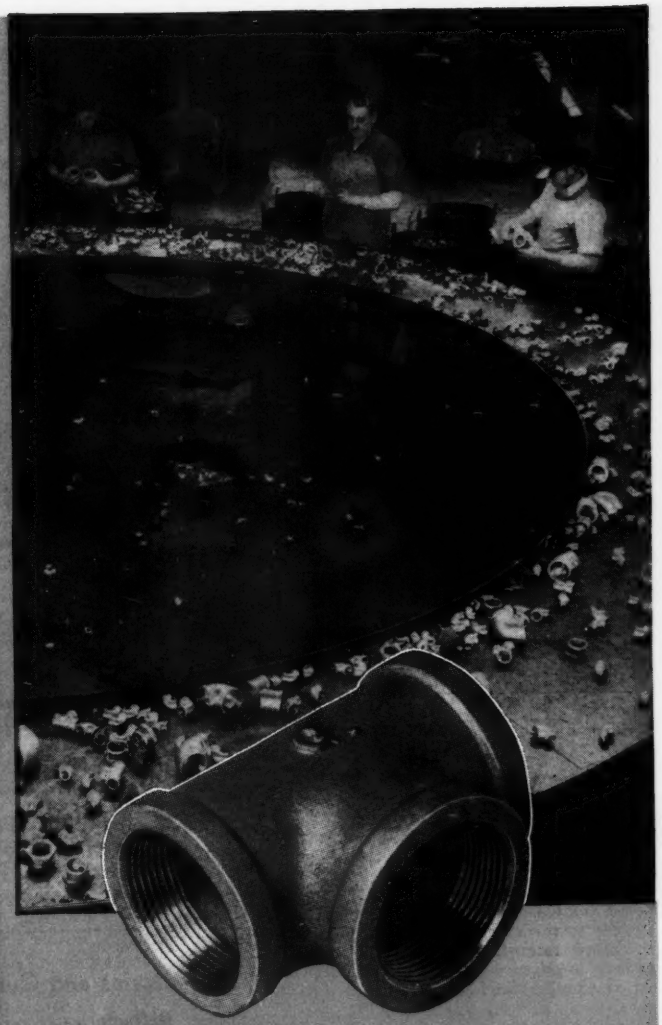


STRENGTH is checked by sample tests in hydraulic machines which force oil under tremendous pressure into the fittings.

CAREFULLY CONTROLLED annealing eliminates strains in the fittings castings . . . gives them rugged strength to take shocks in service.



DIMENSIONAL ACCURACY is checked on test fittings by methods like that shown . . . testing a 2" tee with steel square.



TRIPLE CHECKED...

Up To Grinnell Standard!

To be "right," fittings must be easy to use; make a tight joint; be smooth, inside and outside; and have plenty of rugged strength to withstand service strains. That's the Grinnell standard for fittings, and rigid inspection at three points during their manufacture assures you that every Grinnell Fitting meets that standard.

To make fittings the safest, strongest link in your piping system, choose from the wide Grinnell line. Write for Catalog 4, free on request. Grinnell Company, Inc., Executive Offices, Providence, R. I. Branch offices in principal cities. Continent-wide service through branch offices, wholesalers and heating and plumbing contractors.

CAST IRON . . . AIR FURNACE MALLEABLE IRON . . . STEEL . . . BRONZE FITTINGS BY

GRINNELL

WHENEVER PIPING IS INVOLVED

Roger W. Andrews

ROGER W. ANDREWS has been appointed General Sales Manager of the Riley Stoker Corp., Worcester, Mass. Mr. Andrews has had extensive experience in the steam power field. In 1910 he joined the Northern Equipment Co. and later became secretary and general sales manager of the this company. In 1914, he formed R. W. Andrews Co. of Chicago, handling the sale of power plant equipment in the Chicago territory. A year later, he organized the Andrews-Bradshaw Co., which developed in connection with Tracy Engineering Co., certain specialized boiler room equipment. In 1928 this company merged with the Blaw-Knox Co. and Mr. Andrews became assistant to the president of Blaw-Knox Co. Since August, 1934, Mr. Andrews has been in charge of the Western Division of Combustion Engineering Co.

Roger W. Andrews

Proposed Wyoming Power Development to Cost $100,000,000

THE GREEN RIVER BASIN DEVELOPMENT Co., Perry W. Jenkins, Cora (Sublette County), Wyo., executive manager, recently organized, has made application to the State for water rights covering about 4,085,800 acres in the Southwestern part of Wyoming in the Green River area, for a proposed hydroelectric power and irrigation project. The application has been filed under a law passed at recent session of the State Legislature, providing for the development of the basin through the construction of dams, reservoirs, canals and ditches, to form a system which will include all irrigable lands on the Western slope draining into the Green River. Project is being designed to develop extensive hydroelectric power through construction of main power dam on site selected, with transmission and distributing lines, power substations, switching stations and other operating structures. The entire program will comprise a series of unit developments, with ultimate cost estimated at $100,000,000. This cost will be financed through revenue to be secured through the sale of hydroelectric power, as provided under the Federal Boulder Dam Act.

Delaware Hydroelectric Power Project Opposed

AT A hearing held by the United States Army Engineers at Philadelphia, Pa., July 12, to secure testimony regarding proposed hydroelectric power development on the Delaware River for use of the Committee on Rivers and Harbors of the House of Representatives, Washington, D. C., a large number of protests were entered against the proposition, including those from municipal governments, utility companies, anthracite coal interests, railroads, business concerns and private individuals. Only two expressions of approval were registered, these being from the Chamber of Commerce, Bushkill Falls, Pa., and H. A. Spalinski, who stated he was president of the Electric Power Co. of New Jersey, Trenton.

The proposed development would include the construction of three power dams at Tock's Island, near the Delaware Water Gap, Pa.; at Belvidere, N. J.; and in vicinity of the bridge over the Delaware River, between Easton, Pa., and Phillipsburg, N. J. The estimated cost of the dams and hydroelectric generating stations approximates $30,000,000, of which $21,000,000 would be expended on the first noted, or Tock's Island development. The hearing was preliminary to the appropriation of any funds by Congress for the project.

Mr. James E. Specht Appointed Orrville Municipal Utilities Superintendent

JAMES E. SPECHT, of Orrville, Ohio, was named as superintendent of the Orrville Municipal Utilities at a meeting of the Board of Public Affairs July 24, 1939, to succeed the late A. D. Webster.

Mr. Specht was born at Anoka, Minn., Dec. 26, 1907, graduating from High School in June, 1925, first in his class. In 1929 he graduated from the University of Minnesota, College of Electrical Engineering. Before coming to Orrville Mr. Specht was connected with the Westinghouse Electric and Manufacturing Company.

Since 1931 the Orrville Municipal Utilities' superintendent was employed by the Hagan Corporation, working on electrical devices for controlling boilers and furnaces.

For the Engineer's Library

Recent bulletins and catalogs on power plant equipment listed for your convenience in securing specific information. Power Plant Engineering will be glad to procure for you any free literature that you desire.

Refractories and Cements

Boiler Refractories is the title of a new book which contains valuable data on processes, application, use and construction. It has thirty-two illustrations, is printed in color, and covers the entire field of Boiler Refractory service. The General Refractories Co.

Refractory—Bulletin 102 entitled Cements and Plastics gives a complete story of Narco Bonding Materials, giving principal and general characteristics of each particular brand. North American Refractories Co.

Smooth-On Handbook, 1939 Edition. The information in this booklet represents 40-year experience in improving repair and construction practice—contributed by practical men all over the world, and compiled, put into simple language and illustrated with 170 diagrams to show others how to do important work. Smooth-On Mfg. Co.

Coal and Ash Handling Equipment

Hydrojet Ash Handling Systems are illustrated and described in a new 36-page catalog No. 639B recently issued by Allen-Sherman-Hoff Co.

Coal—A new 40-page catalog gives a complete treatise of Richardson Coal Handling Equipment. The Catalog illustrates and describes the various equipment giving operation and specifications. Richardson Scale Co.

Pumps and Compressors

Compressors—A new line of industrial compressors and vacuum pumps in sizes of from ¾ through 5 hp. is announced in an illustrated catalog, form 7502-J, covering the complete line of Ingersoll-Rand Type 30 Compressors. The catalog contains both installation and shop views of the machines, together with complete operating and physical characteristics of each. Ingersoll-Rand Co.

General Service Motorpump—A new illustrated broadside, Form 1917, showing construction details of the Ingersoll-Rand Motorpump has just been published by the Ingersoll-Rand Company.

Belts and Pulleys

Rockwood Pulleys—Booklet No. 860, covering all types of Rockwood Paper Pulleys for industrial use is particularly useful to everyone interested in plant equipment and its maintenance, since it contains a complete list of stock sizes of pulleys which are always immediately available. Rockwood Mfg. Co.

Power Transmission—Bulletin 75 is a compact edition of power transmis-

TWO GLASSES THAT ARE "TOPS"

. . . . and where to get them

Tragedy does not always result from the breaking of ordinary gauge glasses. Yet there is always a chance that a scalding blast of steam and flying fragments of glass will destroy some man's eyesight or mutilate his face.

Keep this danger away from the doors of your plant. Fit all boiler water columns with SONDERGLASS—the glass which hundreds of engineers regard as "tops" for safety and economy.

SONDERGLASS is extra strong and durable because it is formed of two layers of glass made of semi-metallic substances with different degrees of expansion, thus producing what is virtually a double strength tube. The inside of the tube expands in proportion to the temperature of the steam or water, while the outside resists the shattering effect of sudden cold drafts.

In repeated tests SONDERGLASS has been dipped in hot oil, 450 deg. F., then plunged into cold water without breaking. It has carried up to 1000 lbs. steam pressure without bursting. Also resists clouding and discoloration.

SONDERGLASS comes in the two popular types illustrated: (1) ***CLEAR*** SONDERGLASS for use where the water column is well lighted; (2) ***REFLECTING*** SONDERGLASS with backs of red and white enamel which show better in dark places and make the waterline stand out like a bull's-eye. There is a SONDERGLASS distributor near you. He is interested in giving you "tops" in boiler room protection.

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Washington, D. C. Thos. Somerville Co.
Wallsburg, Conn. . . . . J. Todd & Sons, Inc.
Wilmington, N. C. . . . . Eagle Machine Works

sion data. Design data specification tables and capacity curves on the Morse round pin roller chain are included in the bulletin. Morse Chain Co.

V-Belt Data Book—This book is divided into two parts. The first part covers standard drives eliminating the necessity of working out calculations, and the second, sheave factors for designing new or special drives. It also contains belt comparison tables and other general information. The Manhattan Rubber Mfg. Division of Raybestos-Manhattan, Inc.

Diesel Engines

Diesel Engines—Specifications, mechanical features and application of the "Caterpillar" Diesel D6 Tractor are discussed in a 32 pp. booklet, Form 5403, just published by the Caterpillar Tractor Co.

Diesel Specialties—Catalog No. 5, 52 pp., covering silencers, alarms, controls, instruments, gages, filters, oil reclaimers and other Diesel plant accessories handled by the Diesel Plant Specialties Co.

Electrical Equipment

Generator Set — Bulletin No. 963 gives complete information about Buda-Lanova Diesel Generator Sets. These new standard sets are built in a wide size range from 5 kw. to 75 kw. both a.c. and d.c. The Buda Company.

Electrical Equipment—Catalog 395 illustrates and describes Bull Dog electric products, including Safety switches, service equipment, switch boards, light and power panel boards and bus distribution systems. Prices, specifications and dimensions are included in the catalog. Bull Dog Electric Products Co.

Electrical Equipment—Six new bulletins recently issued cover various types of electrical equipment. Portfolio of Unusual Power Transformers is the title of Bulletin B 6000. Leaflet B6007 treats small auto transformers. Signal transformers in sizes from 500 to 50 v. amp. are described in Leaflet B6008. A new 12-page Bulletin, B6012, describing the latest complete line of vertical-lift metal clad switch-gear, covers the advantages, construction details and uses applying to this latest trend in highly developed switchgear. An enlarged and revised issue of the Indoor Cubicle Type Switchgear bulletin B6011 contains many new installation views, dimension sheets and wiring diagrams, as well as application and construction data. Bulletin B6010 gives list prices, dimensions and applications of a.c. and d.c. motors, as well as typical electrical and mechanical variations for special purposes. Allis-Chalmers Mfg. Co.

Fans and Blowers

Fans. Bulletin 447, 4 pp. showing design and construction of steel plate induced draft fans. Bulletin 446, 28 pp. is a detailed treatment of vane control for mechanical draft fans with characteristic curves, construction details and installation views. B. F. Sturtevant Co.

Motorized Blower Unit for application to high pressures at low speed, is fully described in Bulletin No. CO-3 recently issued by the L. J. Wing Mfg. Co.

Fans—Vane control for mechanical draft fans is described in a 28-page illustrated catalog No. 446, including a discussion of the principle of vane control, comparison of vane control with variable speed and damper control, characteristic curves, application diagrams and installation photographs. Steel Plate Mechanical Draft Fans are illustrated and described in a new 4-page bulletin No. 447. B. F. Sturtevant Co.

Meters and Instruments

Tachometers—Bulletin No. 720 on the Standco Hand Tachometers of the governor type shows a number of new ranges which were recently added to better serve the customers' requirements. This bulletin shows a very complete line of hand tachometers with single, three and four ranges, covering practically any commercial requirements, from 30 to 40,000 r.p.m., and will be of interest to anyone in charge of maintenance or production. Herman H. Sticht & Co.

TAG Celectray Pyrometers and Resistance Thermometers are described in a new 34-page Catalog No. 1101 E. Included are seven new indicating recording or controlling instruments recently developed. C. J. Tagliabue Mfg. Co., Park and Nostrand Avenues, Brooklyn, N. Y.

Instruments—Brown Boiler Room Instruments are completely illustrated and described in a new 16-page bulletin which points out possibilities in fuel saving and the few instruments needed to produce results. Brown Instrument Co. A Division of Minneapolis-Honeywell Regulator Co.

Valves and Piping

The Inside Story of Jenkins 125 lb. Iron Valves is the title of a 24-page photographic study, Form 183, of all iron valve types, analyzing the factors of valve life and maintenance. The booklet concludes with a handy reference chart giving types, sizes and figure numbers for ordering. Jenkins Bros.

Piping—Two new bulletins illustrate and describe the Beaver Model A, portable pipe and bolt machine. The Beaver Model C, a compact power unit which converts hand tools into a portable electric pipe and bolt machine is treated in another bulletin. Beaver Pipe Tools, Inc.

Water Pipe Sizes—A revised 52-page booklet under this title gives concise information and numerous tables, invaluable for making piping layouts and estimates. In addition to rules and tables for determining pipe sizes, water supply formulas and numerous tables showing the flow of water in copper water tube, considerable space is devoted to technical information on the various brass pipe alloys and copper water tubing and their applications. Bridgeport Brass Co.

Expansion Joint—A revised, 12 page illustrated, descriptive Bulletin No. 35-15A has been issued on the ADSCO Piston-Ring Expansion Joint which can be completely unpacked and repacked under full operating pressure without shutting off steam or interrupting service. American District Steam Co.

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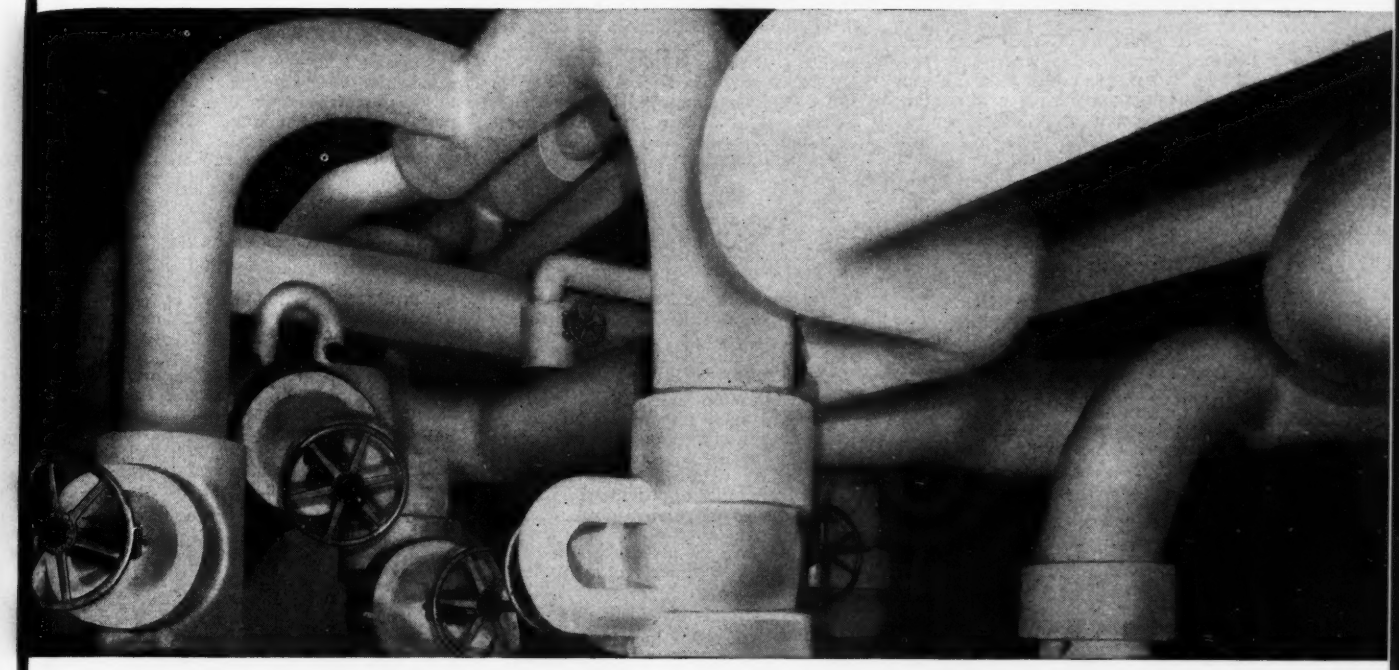

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The engineering department should be well versed in the practical as well as theoretical phases of piping in order to detail and layout the fabricated assemblies as efficiently and economically as possible. In the shop there must not only be equipment for precision bending, welding and machining, but also skilled mechanics who know how to fabricate and heat treat the many different metals used in today's piping systems. Field erection and stress relieving on the job, though greatly simplified by shop pre-fabrication, is a highly complex affair that requires men especially trained in this type of work. Maintaining the construction program, working without interfering with other subcontractors or station operating schedules is an important detail that calls for competent supervision of the field crews.

With a background of nearly 40 years' experience, Pittsburgh Piping KNOWS all these phases of modern piping practice. Whether you are contemplating an extension to your present system or the construction of a new plant, you can be certain that Pittsburgh Piping & Equipment Company can fabricate and erect it correctly and economically. Your nearest Pittsburgh Piping representative is listed below.

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Pittsburgh Piping

Threading Tools and Machines—Catalog No. 39-A, printed in three colors, presents Oster-Williams Threading Tools and Machines in an effective manner and contains time studies, threading speeds, specifications and other information of value to the mechanical man. It contains only essential information so that it is not necessary to search through pages of type to find the facts. Extra large illustrations make it possible to study every detail of each unit. The Oster Mfg. Co.

Master Weight Tables—Technical Bulletin 15 entitled Master Weight Tables for Round Seamless Steel Tubing gives weights per foot for minimum wall and average wall tubes, hot-finished and cold-drawn, ranging in size from ⅛ in. O. D. with 36 B. W. G. wall to 10¾ in. O. D. and 1⅝ in. wall thickness inclusive. The Babcock & Wilcox Tube Co.

Cleaning

Cleaner—A new pocket size folder gives facts about Annite Red Label, the all purpose cleaner. Quigley Co.

Dust the Destroyer is the title of a new book designed to inform users of Motor Control about the advantages of Cutler-Hammer vertical contacts. Cutler-Hammer, Inc.

Dust Collector—Principle of operation and application of the Thermix tubular dust collectors, a special application of the Thermix Multicyclone, is described in a 4-page catalog, No. 7, of the Prat-Daniel Corp., Port Chester, N. Y.

Miscellaneous

Tremendous Trifles is the title of a new booklet which emphasizes the importance of small items of equipment, such as springs, bolts, electrical contact points and the like in making the wheels of industry run smoothly. Sixteen pages in size, with illustrations and charts, it presents technical and mechanical data on nickel, Monel, Inconel, "Z" Nickel, "K" Monel, and other high nickel alloys as used for such parts under service conditions where ordinary materials might fail. The International Nickel Co.

Bearings—A new bulletin entitled The World of Tomorrow Rolls On Timken Roller Bearings Today shows how and where Timken roller bearings are used at the New York World's Fair. Timken Roller Bearing Co.

Metallo Gaskets are illustrated and described in a new 16-page catalog giving dimensions and list prices. Metallo Gasket Co.

Analysis of Summer Weather Data in the United States—Bulletin 802 presents the first chapter of a book written by J. C. Albright which is the first and only complete and practical source of data on Weather. The Marley Co.

Drainers—Cochrane drainers of the external cage type, for continuously removing large quantities of condensate under high pressures, are illustrated and described in publication 2930. Cochrane Corp.

Research—Treatment of coal and oil and other petroleum products, quantities needed per ton, the proper oil to use with different coals and details of a 2½ yr. research program at Battelle Memorial Institute, and reported by J. M. Pilcher and Ralph A. Sherman, has recently been published as Technical Report No. VI by the Bituminous Coal Research, Inc., 807 Southern Building, Washington, D. C. Copies of this 36 pp. bulletin may be obtained free of charge from the above organization or from The Standard Oil Co. of N. J., 26 Broadway, New York City; the Sun Oil Co., Philadelphia, Pa., or the Viking Manufacturing Company, Jackson, Mich.

Metals—Typical Nickel Alloy Steels and Cast Irons employed in Diesel engine construction are given in a new bulletin. Nickel Alloy Cast Iron in gas manufacturing equipment is the title of a bulletin in which a revised article by J. S. Vanick is presented. The Internationl Nickel Co., Inc.

Super-Centrifuges—A general term applied to a certain group of Sharples Centrifugals is the topic of discussion of Bulletin 1225. Reproduction of blue prints explain the mechanical features of design and details of the varied types of motive power that may be used. A brief cataloging of the leading types of Super-Centrifuges completes this 20-page bulletin. The Sharples Corp.

Ship Building—A full description of vessels and their equipment is given in an article entitled "Renaissance of Pacific Coast Shipbuilding," which has been reprinted and is being distributed by the De Laval Steam Turbine Co.

New Engineering Books

Power Factor Economics. By Price L. Rogers. First Edition. 143 pages, 30 illustrations, 6 by 9 cloth. John Wiley and Sons, Inc., 440—4th Ave., New York, N. Y. 1939. Price $2.50.

Power factor is dealt with in this book as it applies to industrial plants and distribution systems of public utilities. Its purpose is to answer the questions which arise when power factor is considered and to provide simple, accurate means of solving power factor problems. In other words, it is a very practical book useful to the man who has to deal with power factor problems in a practical way.

The effects of power factor on utility distribution systems and in the industrial field have been receiving an ever-increasing amount of attention, and it is here that the demand for accurate information exists. The technical education of the interested individuals varies from none to that attested by university degrees. The author's aim in this book therefore, has been to supply the information in a form simple enough to appeal to the first group and yet not too elementary for the second.

An idea of the book's scope may be gained from the chapter headings which are, as follows: Power Factor. Motors. Transformers. Capacitors. Problems and their Solution. Industrial Power-Factor Studies. Conductor Losses. Utilities' Distribution Systems. Index.

Tool Making. By C. B. Cole, Published by the American Technical Society, Drexel Ave. at 58th St., Chicago. Size 5½ by 8½ in., 413 pp., cloth bound. Price $3.50.

Although the power plant engineer cannot be classed as a toolmaker, his many duties often require him to have an intimate knowledge of machine tools, heat treating process and production methods either directly or indirectly through his contact with industrial departments. Mr. Cole is, among other things, president of the Tool Equipment Sales Co. of Chicago and this book is well adapted not only to the needs and requirements of the toolmaker but to that of the general engineer as well. It is one of this company's well known "how-to-do-it" series and the young engineer especially will be interested in such practical phases as: how to read a micrometer, a dial indicator, etc.; how to use a Rockell Hardness Tester, an electric etcher, Vernier calipers, Johansson gage blocks, etc.; how to grind tools, dress a grinding wheel, do polishing and lapping, etc. For the experienced toolmaker the sections on production tools are especially valuable. Drawings and illustrations are presented as working drawings and the tools which they represent may be made from these drawings.

Utility Chart, 1939. Published by Robert A. Burrows, First National Bank Bldg., Pittsburgh, Pa. Size 34 by 28 in. Price: one color, $2.00 per copy; colored, $3.00 per copy (25 cts. extra for mailing unfolded. Quantity prices for 10 or more copies).

This a most unique chart which in ten years has grown from a hobby into a reference work invaluable to all interested in any phase of the public utility industry. It shows at a glance the interreiation, capitalization, service areas, etc., of 45 of the principal utility systems, including electric light and power, gas, transportation, water, communication, investment, etc. New data on the 1939 chart includes Service Area Maps, competitive government power districts, flow of 1938 dividend, interchange contracts for power and gas, gross revenues and funded debt.

Look and Listen. The Television Handbook. By M. B. Sleeper. First edition. 6½x9 in. spiral wire binding. The Norman W. Henley Publishing Co., 2 West 45th St., New York, N. Y. 1939. Price $1.00. Cloth binding, $1.50.

With the advent of television service in New York city early this year, the subject of television is becoming of increasing importance to the general public. This little book is a practical consideration of the subject written in understandable language and in addition presents detailed instructions for building a television receiver. It is well illustrated with photographs and diagrams and includes a set of large scale wiring diagrams which are remarkably easy to follow. For anyone interested in building a television receiver, this is an excellent little book. M. B. Sleeper, the author, is the founder and editor of Radio Engineering Magazine and has been actively identified with the radio industry since 1916.

Now No. 1799 Becomes the G-E Standard for Varnished-cambric Cable

New Savings, Longer Life—
No Increase in Price

I. P. C. E. A.
No. 1799 meets the new I.P.C.E.A. specifications for Varnished-cambric-Insulated Cables (Fourth Edition, July, 1939).
Bulletin GEA-3215 contains the new operating temperatures.

THE new G-E heat-resisting varnished cambric, No. 1799, has now become the G-E standard—thus making available a special product at no extra cost.

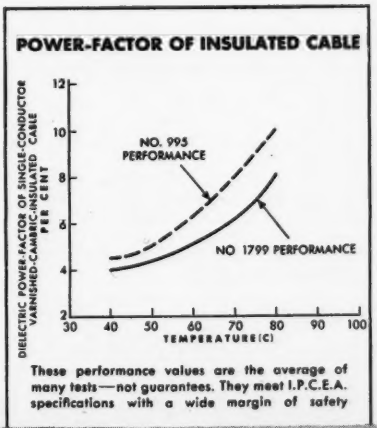
The obvious superiority of No. 1799 led to this decision. Its superiority lies in the combination of heat resistance *plus* high dielectric strength and low dielectric (power-factor) losses. See curve for example; other values are given in Bulletin GEA-3215.

Lower Cost

Cable insulated with No. 1799 can be run at a conductor temperature of approximately 10 C higher than cable insulated with No. 995 varnished cambric, our previous standard.

This means new savings, by making it possible to reduce conductor size and thus copper—particularly on low-voltage lines—with corresponding reductions in first cost, over-all diameter, shipping weight, duct space, and other respects.

But this is not all. In addition, a new process of cable manufacture has greatly improved the dielectric power-factor of our varnished-cambric cable and has added years to its life.



These performance values are the average of many tests—not guarantees. They meet I.P.C.E.A. specifications with a wide margin of safety

A Good Product Made Better

No. 1799 supersedes No. 995 varnished cambric, our standard for many years. Cable insulated with it has a fine performance record. Fortunately, therefore, our engineers did not have to throw No. 995 into the discard. They retained the same special G-E cloth, "unsized" to assure thorough impregnation. They kept the asphalt base, but with it obtained a superior varnish. They made other detailed improvements. And the resultant insulation, No. 1799, is the new standard for G-E varnished-cambric cable—*at no increase in price.*

Bulletin GEA-3215 gives details. For a copy and a sample of No. 1799, address the nearest G-E sales office, or General Electric, Dept. 6-201, Schenectady, N. Y.

GENERAL ELECTRIC

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Public Personnel Problems. By Lewis Meriam. Published by The Brookings Institution, Washington, D. C. Size 5 by 8 in., 440 pp., cloth bound. Price $3.00.

As an operating officer immediately responsible for getting a certain specific task done or for rendering a specific governmental service, the author has successfully endeavored to treat the subject from his viewpoint. The book presents the public personnel administration as a whole and deals with the subject as simply and as realistically as possible, making free use of illustrative cases.

Viewing the subject as a whole, the author has divided the subject into three main branches: (1) operating personnel administration; (2) control personnel administration; (3) developmental personnel administration. Each division is defined and treated so as to show the reader just who is represented in each class. The United States Civil Service Commission is discussed in detail showing how employes are selected and by whom, and the procedure which is followed after selection.

Although the book was primarily intended for executives of the government, it should prove helpful to the executive in private industry.

Industry Standards and Engineering Information. Published by the A. B. M. A. Fair Practice Committee, Boiler Manufacturing Industry, 15 Park Row, New York, N. Y. Size 8½ by 11 in., 43 pages, loose-leaf, paper cover. Price $1.00.

This is in effect a manual of the boiler and affiliated industries prepared primarily for the information of those writing specifications for steam generating equipment so that misunderstanding will be prevented. Contracts should define clearly the equipment to be furnished, the work to be done, conditions on which statements of performance are made and supplementary clauses covering general conditions and the purchaser should receive all needed information on which to base his selection of the equipment. Experience with the Standard Performance Form has proven that the data supplied is sufficient not only for equipment selection but also to give an accurate measure of performance. The manual contains general contract conditions, performance forms for various types of equipment, statement relative to mechanical draft fan equipment, grindability values for various coals.

Summer Cooling in the Warm-Air Heating Research Residence With Cold Water. By Alonzo P. Kratz, Seichi Konzo, Maurice K. Fahnestock and Edwin L. Broderick. Issued by the Engineering Experiment Station, University of Illinois, Urbana, Ill., as Bulletin 305. Size 6 by 9 in., 89 pp., paper bound. Price $0.90 (limited number of copies available for free distribution).

During the seasons of 1932-1936 a study was made of the possibility of cooling a residence in summer by various means. The work done and the results obtained during the summers of 1932, 1933 and 1934, using ice and mechanical refrigeration, have been reported in Bulletin 290. Bulletin No. 305 covers the work done during the seasons of 1935 and 1936 to determine to what extent water from the city mains, available at temperatures of from 58 to 60 deg. F. (and also cooled to 52 deg. F. and 46 deg. F.) could be used to produce satisfactory cooling and dehumidification. A study was also made of the performance of different types of registers used in connection with summer cooling work.

Patent Tactics & Law. By Roger Sherman Hoar. Pubished by The Roland Press Co., New York, N. Y. Size 5⅛ by 8½ in.; 288 pp., cloth bound. Price $4.50.

Mr. Hoar, formerly assistant attorney general of Massachusetts and now commercial attorney of Bucyrus-Erie, is also an engineer, mathematician and inventor. From this broad background, he differs with the common opinion of business executives and lawyers that patent tactics should be left strictly up to the attorney. With this in mind he has completely revised his earlier book Patents and added to the translation of patent law a treatise on patent tactics. He does not try to make the executive an attorney but proceeds on the basis that the executive should be able to understand the company's attorney so as to be able to cooperate fully with him.

He outlines a clear-cut policy for protection against loss of patents and against maneuvering by competitors; the means to a thorough understanding of proper legal procedure to follow in situations involving patent rights; shows how to organize a patent department and protect patents here and abroad; gives a comprehensive explanation of the business aspects involved in the evaluation of patents and patent licenses; how to carry these values on the books and how to account for them for tax purposes.

The book is not abstract theory but the outgrowth of many years of experience as a patent attorney dealing with executives and engineers and first appeared in mimeographed form for use in the company. The first edition represented a slight amplification of these mimeographed notes but the present edition is a complete revision made in the light of 12 yr. experience. The present text is well supported by illustrative examples, which combined with Mr. Hoar's fluid style, make the book entertaining reading, quite aside from its value in connection with patents and patent law.

Summer Weather Data, compiled and edited by J. C. Albright. Published by The Marley Co., Kansas City, Kan., 180 pages, 8½ by 11 in. Price $3.00. First edition, 1939.

Designers of heat exchange systems will find in this book a vast amount of data on weather factors that will be helpful in selecting the most economical combination of equipment for any locality in the United States. It is replete with weather maps and statistical data compiled from every locality in the country including wet bulb, dry bulb and dew point temperatures, atmospheric pressures, humidity, precipitation, wind direction and velocity, latitudes and elevations of locations, and sunshine data. The book also contains information on how the statistical data may be used in the design of air conditioning equipment.

Power. By Bertrand Russell. First edition. 315 pages size 6 by 9, cloth. Published by W. W. Norton and Co., New York, N. Y. 1938. Price, $3.00.

In presenting a review of this new book by Bertrand Russell it is not our intention to mislead readers of this magazine into believing that it deals with the kind of power they are most familiar with. At the outset we tell you, frankly, that this book does not deal with the physical power of matter in any of its forms, mechanical, electrical, thermal, etc., but rather with social power, the power of men over men.

Here, as in all things, however, the lines of demarcation are indefinite. As the author shows, it is possible to establish a technicological power over men which is based on power over matter. "Those" he says, "who have the habit of controlling powerful mechanisms, and through this control have acquired power over human beings, may be expected to have an imaginative outlook towards their subjects which will be completely different from that of men who depend upon persuasion, however, dishonest." Mechanical power tends to generate a new mentality which makes it more important than in any former age to find ways of controlling governments.

While this book should be of interest to every intelligent person whatever his walk of life or his calling because of this interrelationship between social power and technicological power it should be of particular interest to engineers concerned with the latter class of power. Technical considerations, broadly speaking, have led to an increase in the optimum size of organization suitable for dealing with a given matter, and with this increasing size and complexity of our organizations—our society in general, it is unquestioned that this state should act for the greatest good of the greatest number. But, as Mr. Russell points out in this book, unless individual liberties are somehow safeguarded, a new tyranny may be established more drastic and terrible than any previously known.

Characteristically enough, Bertrand Russell approaches this question with the same meticulous care that he did in his great work which established the fundamental relation between mathematics and logic. He shows that power is the fundamental concept in social science just as energy is the fundamental concept in physics. Power, like energy, he maintains, must be regarded as continually passing from any one of its forms into any other, and in this book he seeks to find the laws of such transformations. Throughout the book are those extraordinary flashes of wit, that incisive cutting through conventional humbug to fearless statement of what is really happening which makes Bertrand Russell probably the greatest living master of English expository prose.

The Microscope in Elementary Cast Iron Metallurgy. By Roy M. Allen. Published by the American Foundrymen's Association, 222 W. Adams St., Chicago, Ill. Size 6 by 9 in., 160 pages, waterproof cloth binding. Price $3.00.

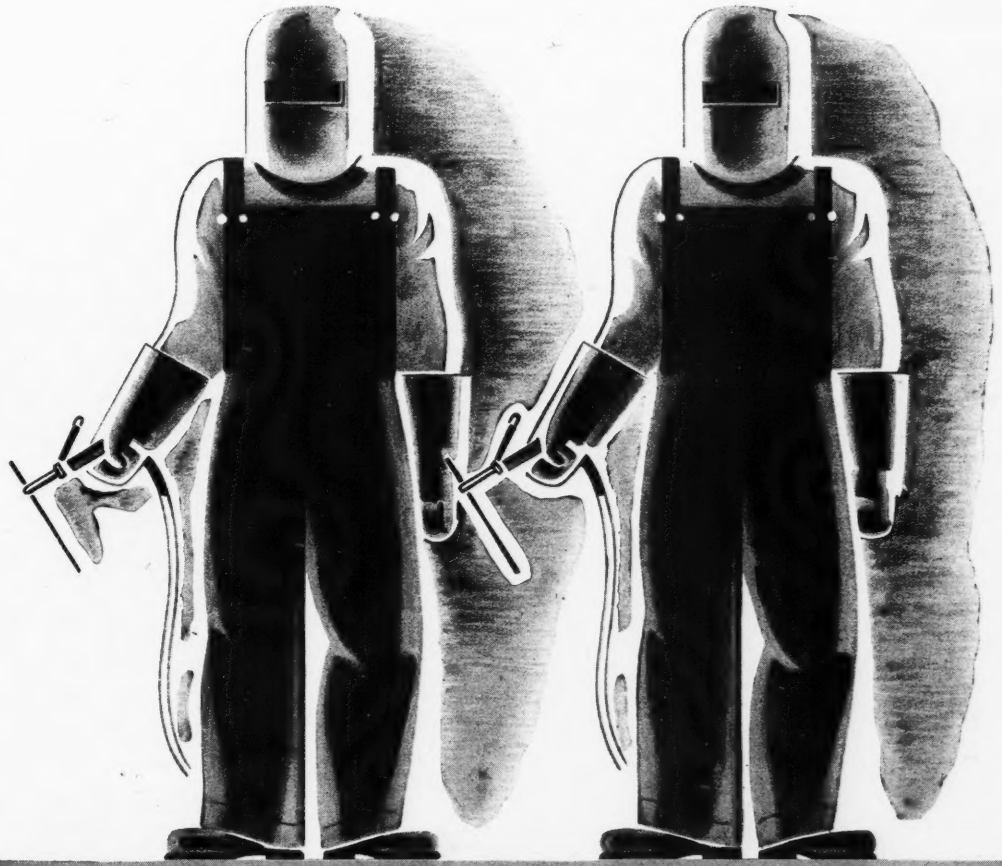
This is an enlargement of the material presented at a series of lectures at the 1939 Convention of the A. F. A.

WELDERS LOOK ALIKE but—

Unfortunately, you can't judge the ability of a welder by his appearance . . . or the quality of a weld by its appearance. This is one important reason why pressure piping can best be secured from a *qualified* pipe fabricator.

The qualified fabricator employs skilled pressure welders who work under the most favorable conditions. They are closely supervised to make certain they exactly adhere to predetermined welding procedures that have been proved correct for the particular jobs. The production of these welders is checked at frequent intervals by destruction tests to make sure the high standard is being maintained; this welding can be insured.

The qualified pipe fabricator delivers the piping to the job as a series of carefully prepared, shop tested sub-assemblies, that are readily and economically installed.



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and covers the value of the microscope to the foundryman and the fundamentals of physical cast iron metallurgy. The microscope and the technique of its use in focussing, taking microphotographs, photographic processes, photographic papers, etching reagents, etc., are discussed in detail. Not only is the procedure for securing, grinding, polishing, etching, observing and photographing samples explained, but of what is seen in the microscope and in the microphotograph is fully interpreted.

Alloy Cast Irons. Published by the American Foundrymen's Association, 222 W. Adams St., Chicago, Ill. Size 6 by 9 in., 270 pages. Flexible fabricoid binding. Prices $3.00.

This book, a project of the Gray Iron Division of the A. F. A., covers the effect of 18 different elements on the various properties of gray, white and chilled cast irons. It discusses the forms in which alloying elements are commercially available, general foundry practice used in the production of the irons, and covers the composition, mechanical properties, uses and service data on many types of alloy cast irons commercially available.

Air-Conditioning Engineers' Atlas by Clifford Strock and C. H. B. Hotchkiss. Published by The Industrial Press, 148 Lafayette St., New York, N. Y. 76 pp., including 18 colored maps; size 9 x 12 in. Price $2.00.

This is a new type of book presenting in condensed and usable form climatic data needed for the solution of heating and cooling problems. The Atlas consists of 18 sections, each containing a colored map of the United States, accompanied by pertinent data in tabular form; of these 18 sections nine deal with winter weather conditions and nine with summer weather conditions.

For the heating and air conditioning application engineer the Atlas furnishes extreme weather data required in calculating plant capacity. For the operating engineers it provides average climatic data for predicting operating quantities and obtaining good operating results. It is also useful in determining the potential markets for heating and air conditioning equipments and fuels, so far as climate is concerned.

The maps in the Atlas cover 18 full pages, are printed in three colors and black, are unusually legible, and enable the determination of the desired figure for all parts of the United States.

Heating, Ventilating and Air Conditioning Guide 1939. Published by the American Society of Heating & Ventilating Engineers, 51 Madison Ave., New York, N. Y. Size 6 by 9 in., 856 pages plus 416 pages catalog section and membership list, flexible fabricoid binding. Price $5.00. De Luxe Edition containing thumb index, $5.50.

This is the 17th edition of the official reference book compiled by the society and published for engineers, architects, contractors, schools and colleges, purchasing agents, manufacturers, public utilities and others engaged in the field of heating, ventilating and air conditioning. It contains the largest technical data section of any of the annual reference volumes that have been published. Some 45 chapters cover design and specifications of heating, ventilating and air conditioning systems.

Those chapters dealing with central systems for heating, humidifying, cooling and dehumidifying have been carefully reviewed and a completely new chapter has been prepared which is entitled Central Systems for Comfort Air Conditioning. Information on heat transfer surface coils for summer and winter application has received special attention not given in previous editions. The chapter on Combustion and Fuels has been completely revised.

In addition to the technical material, over 270 pages of manufacturers catalog data are included, as well as an index to modern equipment listing 300 items, cross-indexed as to product and manufacturer.

Engineering Terminology. By V. J. Brown and D. G. Runner. Published by the Gillette Publishing Co., 330 S. Wells Street, Chicago, Ill. Size 6 by 9 in.; 439 pages; cloth bound. Price $4.00.

This is the second edition revised and enlarged for the book fills a decided need in engineering literature. The enginering field has become so large that it is difficult, if not impossible, for any one individual to be familiar with the vocabulary of all branches. The fields covered include highways, streets, investment, waterworks, sewerage, geology, structures, architecture, air conditioning, marine, economics, railroads, etc. Several appendices include foreign terms, conversion units, suggested symbols and other data of a practical nature.

An Introduction to Vector Analysis for Physicists and Engineers. By H. Hague, First Edition. 118 pages, illustrated. 4 by 6½ cloth. Chemical Publishing Co. of N. Y., Inc., 148 Lafayette St., New York, N. Y. 1939. Price $1.50.

The purpose of this handy little volume is to provide physicists and engineers with a concise explanation of the fundamental principles of vector analysis omitting all unessential detail of purely mathematical interest. Vector analysis is the natural means of expression for the three dimensional problems of physics and engineering because its conciseness and freedom from mathematical detail enable the relationships between various quantities to be kept clearly in view. Much good work with vectors can be done with the aid of a few very elementary principals and it is the object of this monograph to give an introduction to these principles and explain them from a physical standpoint so that they may be easily available to the busy physicist or engineer approaching the problem for the first time. Dr. Hague, the author is lecturer in electrical engineering at the University of Glasgow and this monograph is based on a course of lectures given a few years ago to post-graduate electrical engineering students in the Polytechnic Institute of Brooklyn, N. Y.

Machine Design. By Stanton E. Winston. Published by the American Technical Society, Drexel Ave. at 58th St., Chicago, Ill. Size 5½ by 8½ in.; 326 pages; cloth bound. Price $3.00.

Machine design is broad in its scope and offers great opportunity for specialization. The basic fundamentals of theory and analysis is, however, common to the entire field and this text is a simple, direct and comprehensive treatment of these fundamentals. The author is associate professor of mechanical engineering at Armour Institute of Technology and approaches the subject in a practical manner, assuming only that the reader has some knowledge of mechanism and a knowledge of mathematics extending through trigonometry and logarithms. Calculus is not used. The book is divided into nine chapters including simple and compound stresses, bolts and screws, cylinders and riveted joints, shafting and keys, couplings and clutches, wrapping connectors, friction drives and gears and miscellaneous details of design. It is well illustrated by sketches and by photographs.

The Superheater in the Modern Power Plant. By D. W. Rudorff. Published by the Pitman Publishing Corp., 2 West 45th St., New York City. Size 5 by 8 in.; 258 pp.; cloth bound. Price $6.00.

In spite of the importance of superheat in modern power plant engineering, the author feels that the superheater has received a one-sided treatment in technical literature, that its theoretical aspects have been overtreated while the actual ways and means of superheating have found only occasional and passing comment. This book is an attempt to bridge the gap in literature. It opens with a short discussion of the economic advantages of superheated steam and then discusses in considerable detail the fundamentals of superheater computation, not from the standpoint of minute procedure but to facilitate an understanding of the theoretical foundations.

Superheater engineering necessarily entails a description and discussion of the different types of boilers with which they are used and which necessarily affect the design and operation of the superheater. Principles of superheat regulation, types of superheaters, their application to modern boilers, desuperheaters and reheaters are followed by chapters on mechanical design and operation. A 21 page appendix with the Keenan steam tables is included.

This book was originally published in England and thoroughly covers English and Continental practice. A large number of the illustrations are, however, selected from American plants so that the book has an international aspect and treats the most advanced practice throughout the industrialized section of the world.

Simple Blueprint Reading with particular reference to welding and welding symbols is the title of a new booklet which contains 140 mimeographed pages, 8½ by 11 in., bound in durable paper. Price $0.50 in United States, $0.75 elsewhere.

The booklet gives the student a comprehensive explanation of various symbols used in drawings of different types of welded joints. The 85 illustrations contained in the book include practical examples of drawings of a number of machine parts, pipe connections and general construction. The booklet also contains a list of questions and answers. The Lincoln Electric Co.

Top-Quality JENKINS iron VALVES

mean extra savings!

CHECK the features in the diagram below and you'll see the sound valve engineering behind this Jenkins Fig. 624, 125 lb. Regrinding Swing Check Valve.

But the real superiority of Jenkins Iron Valves is proved in service.

Throughout industry, "veteran" Jenkins Iron Valves . . . valves with 20, 30, 40 years of trouble-free service . . . are demonstrating that Jenkins design and construction mean worthwhile savings in maintenance costs.

And when you get this better valve investment at standard "Good Valve Prices"—Jenkins Iron is obviously your best buy.

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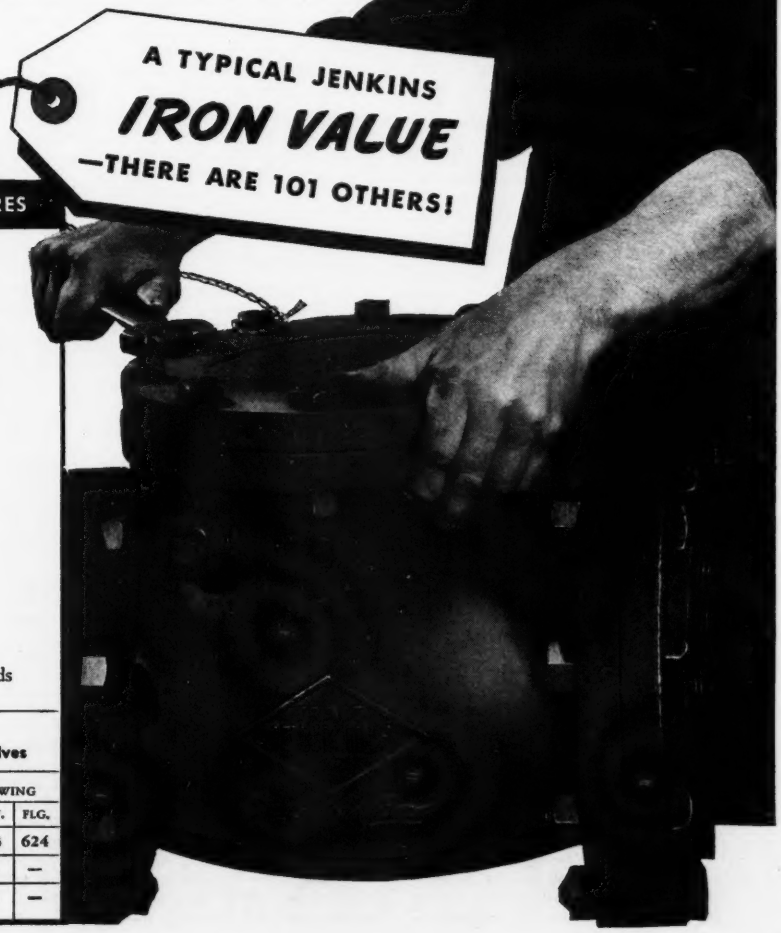

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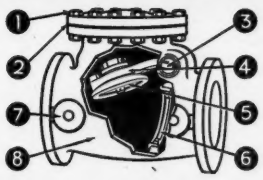

1 Rugged Through-Bolts
2 High Pressure Asbestos Gasket
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6 Renewable Bronze Seat Ring
7 Convenient Bosses
8 IRON *Exceeds* A.S.T.M. Standards

Guide to Figure Numbers of Jenkins Iron Body Regrinding Check Valves

STEAM PRESSURE	HORIZ. LIFT		ANGLE LIFT		SWING	
	SCW.	FLG.	SCW.	FLG.	SCW.	FLG.
125 Lbs.	617	618	619	620	623	624
150 Lbs.	928	929	930	931	—	—
250 Lbs.	934	935	936	937	—	—

Arc Welding in Design, Manufacture and Construction. Published by The James F. Lincoln Arc Welding Foundation. P. O. Box 5728, Cleveland, O. 1408 pages, 695 illustration, size 6 by 9, semi-flexible leather. Price $1.50 postpaid in the U. S. A., $2.00 elsewhere.

This volume comprises 109 selected studies from the James F. Lincoln Arc Welding Foundation Award Program. These papers contain a wealth of design, manufacturing and construction data, covering a great variety of subjects and conveniently arranged in ten sections. With few exceptions the papers are reproduced in complete form. Only those which were too lengthy for inclusion in their entirety are in the form of comprehensive briefs.

The ten sections cover every phase of arc welding practice and are entitled as follows:

1, Automotive. 2, Aircraft. 3, Railroad. 4, Watercraft. 5, Structural. 6, Furniture and Fixtures. 7, Commercial Welding—Automotive—Repair—Welderies. 8, Containers. 9, Machinery. 10, Jigs and Fixtures.

These papers in their collected form provide the engineering profession, students and schools with new, useful, scientific data and should be of value to engineers, designers, architects and production officials.

Methods of Analyzing Coal and Coke, a revised edition of Technical Paper 8, has recently been published by the Bureau of Mines, Department of the Interior. This paper, revised by A. C. Fieldner and W. A. Selvig, includes much material not found in the former editions. This new material consists of methods of analysis of coal and coke ashes, determination of iron forms in coal ash slags and clinkers, determination of sulphur forms and carbon dioxide in coal, and agglutinating or caking characteristics of coals as determined by examination of the residue in the crucible incident to the standard test for volatile matter.

Revisions have been made in many of the methods given in the former editions of the publication, which methods include proximate and ultimate analysis, methods for phosphorus, calorific value, specific gravity, fusibility of coal ash, and shatter test for coke. The methods as published describe the current procedures as used in the laboratories of the Bureau of Mines.

Technical Paper 8, "Methods of Analyzing Coal and Coke," is available by purchase from the Superintendent of Documents, Government Printing office, Washington, D. C., at a price of 15 cents per copy.

How to Buy, Sell and Burn Coal. By Thomas A. Marsh. Published by Thomas A. Marsh, 5625 Kenwood Ave., Chicago, Ill Size 4¼ by 6½ in. 97 pages. Price: Single copies $1.00, 10 to 24 copies 90c each, 25 or more copies 80c net, including U. S. postage.

Written for the guidance and assistance of anybody technically or non-technically trained, this book will undoubtedly be of help to those concerned with fuel distribution as well as fuel utilization. The chapter entitled Schematic Analysis of Troubles is of exceptional interest, covering such topics as Load difficulties, Stoker difficulties, Furnace difficulties, Control difficulties, Fuel difficulties and Operation difficulties. Each topic is discussed in detail giving the causes of such a condition. The final chapter gives General Combustion Information.

Piping Handbook. By J. H. Walker and Sabin Crocker. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York. Size 4½ by 7 in., 877 pages. Price $6.00.

This is the third edition of one of the most widely used and practical handbooks prepared for the engineering field for the authors, Superintendent of Central Heating and Senior Engineer of the Engineering Division, respectively, of The Detroit Edison Co., have approached the subject from a thoroughly practical standpoint.

The first edition appeared in 1930, the second edition with minor changes in 1931. During the years since 1931 there has been considerable change in piping practice, due to: welding, use of ready made fittings and temperatures of 750 to 950 deg. F. in the power plant field. There have also been some new methods of pipe manufacturing and considerable standardization work carried on by the various engineering societies so the third edition has been thoroughly revised and enlarged to meet present day practice. These changes are particularly noticeable in the chapters on metallurgy of piping materials, pipe, valves and fittings, heat insulation, steam power plant piping and oil piping.

Pipe and Piping Material Specifications. Published by the American Society for Testing Materials. 260 S. Broad St., Philadelphia, Pa. Size 6 by 9 in., 128 pp., spiral binding with stiff cardboard cover. Price $1.25.

For many years A.S.T.M. Committee A-1 on Steel has been developing specifications covering steel materials for high temperature service. These standards have been issued and published as available either as separate pamphlets or in the regular Book of Standards. Eighteen such specifications covering carbon steel and alloy-steel pipe and tubing, castings, forgings and bolting have been made available in this convenient, compact form.

Diesel Hand Book. By Julius Rosbloom. Published by the Diesel Engineering Institute, 137 Franklin St., Jersey City, N. J. Size 5 by 7 in.; 705 pp., flexible fabrikoid binding. Price $5.00.

This is the sixth edition of a practical book designed as a combination handbook and textbook dealing with the Diesel. Much of the text is in the form of questions and answers, with particular stress on license examinations.

Diesel Engines, Theory and Design. By Howard E. Degler. Published by the American Technical Society, Drexel Ave. at 58th St., Chicago, Ill. Size 5½ by 8½ in.; 266 pages; cloth bound. Price $2.50.

Written primarily for students, designers and draftsmen, with the assumption that the reader has a working knowledge of mechanics and the common gasoline engine, this book will have a wide appeal both for class room, home study and reference purposes. Although the book assumes a knowledge of fundamental principles of mechanics, the material referring to Diesel engine theory, application, performance and design is developed completely from first principles. It covers thermodynamics, fuels and combustion, testing and performance, fundamental principles of engine design and design of the major parts. One of the most interesting and perhaps valuable parts of the book is the large number of examples which have been worked out in detail. Most of these examples refer to a specific engine, details of which are given on a two-page reference table, with complete characteristics and dimensions of this engine.

Protective Coatings for Metals. By R. M. Burns and A. E. Schuh. Published by the Reinhold Publishing Corp., 330 W. 42nd St., New York, N. Y. Size 6 by 9 in.; 385 pages; cloth bound. Price $6.50.

Corrosion and corrosion protection are playing an increasingly important part in industrial problems and great advances have been made during the past decade in the technique of protecting metals by coating them with other metals, paint, lacquer or enamel. This entire subject is covered most comprehensively in the present work which is an outgrowth of Rawdon's Protective Metallic Coatings which appeared in 1927 as one of A. C. S. Monograph series. The present work which started out as a revision, covers a much broader field and is in effect a complete new book. Dr. Burns is Assistant Chemical Director of the Bell Telephone Laboratories and Dr. Schuh is Director of Research of the U. S. Pipe and Foundry Co.

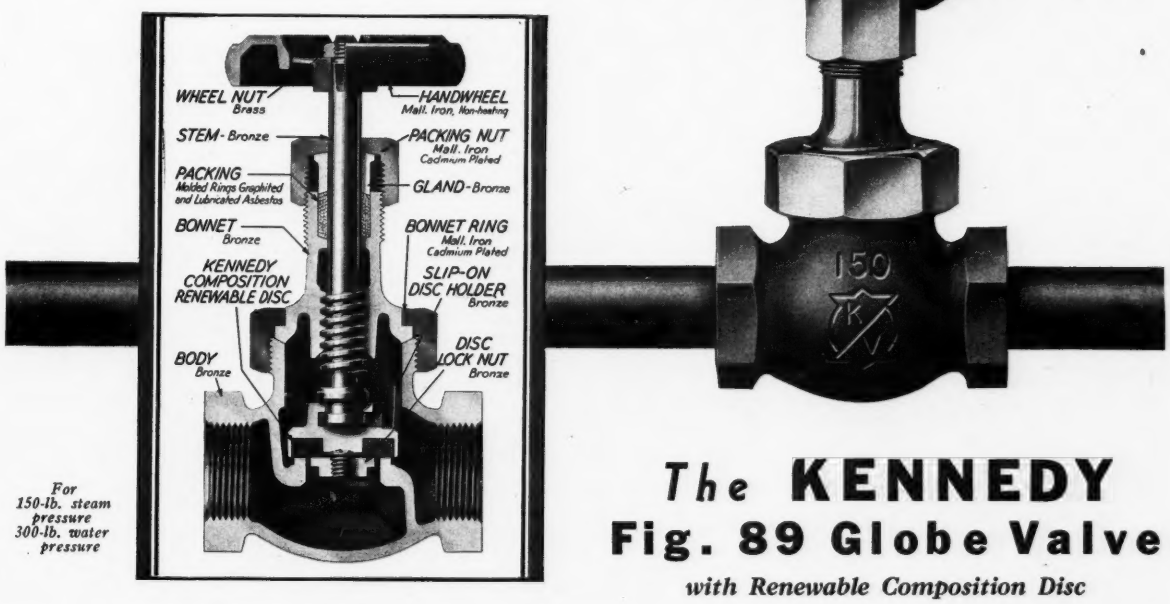
The book covers all phases of protection by coating, surface preparation for the application of coating, all types of metallic coatings including the noble and rare metals, methods of testing metallic coatings, composition of paints and mechanism of film formation, durability and evaluation of paints, paint practices and miscellaneous coatings. It is designed primarily for those who have problems of protection for it discusses long time exposure tests which have yielded much of the basic information on this subject, tells how protection is provided for a wide variety of industrial products, critically discusses the composition and properties of paints, lacquers and enamels, with particular emphasis on synthetic resin vehicles.

1938 A.S.T.M. Proceedings. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. Size 6 x 9 in., Vol. I 657 pages; Vol. II 1342 pages. Price for each volume, paper $5.50, cloth $6.00, half leather $7.00.

These Proceedings are published in two parts. Part I deals with the reports of some 50 committees outlining important standardization and research work accomplished. Practically 60 per cent of Part I consists of tentative standards issued or revised in 1938 and covering all steels and materials. Part II is made up of 45 technical papers, the Edgar Marburg Lecture on The Torsion Test and extensive discussions of the papers. Ten of the 45 papers comprise the Symposium on Impact Testing; 13 relate to ferrous and non-ferrous metals; eight to cement, concrete, ceramics, etc., while the remaining 12 papers cover a number of miscellaneous subjects including adherence of organic coatings to metals, rosin crystallization, oxidation of transformer oil, etc.

A heavy standard bronze globe valve

for better service, longer wear, and easier maintenance



For 150-lb. steam pressure 300-lb. water pressure

The KENNEDY Fig. 89 Globe Valve

with Renewable Composition Disc

Some Additional Features of Kennedy Fig. 89

Disc holder has four prongs for guidance and to prevent binding

Raised seat in body is unusually high for longer disc life

Slip-on disc holder locks at wide-open position

Stem has large number of heavy contact threads to reduce wear

Conical joint between stem and bonnet permits packing under pressure

Stuffing box is exceptionally deep with molded packing and long gland follower

THE first things you will notice on examining a Kennedy Figure 89 Valve are its sturdy proportions and its attractive appearance. A specially interesting feature is the smooth silver cadmium plating on the malleable iron union bonnet ring and packing nut. This distinctive finish will not chip off nor be easily marred from wrenches, provides permanent protection against rusting, and has a self-lubricating quality on the threads.

When you try out the operation of this new valve, notice how easily the valve opens and closes. This is because of a special machined low-friction contact surface between the stem head and the disc holder. Notice also the comfortable grip on the octagonal non-heating hand-wheel with the wheel nut below the level of the wheel so that it cannot burn the palm of the hand.

The outstanding features of Kennedy Fig. 89 makes it a distinct advance in heavy standard bronze globe valve design. Order some of these valves from your distributor and try them out at the first opportunity. You will find their easy operation, low maintenance expense and long life make them the best possible valve investment.

The Kennedy Valve Mfg. Co., Elmira, N. Y.

KENNEDY VALVES with Extra Value

Power Plant Construction News

Ala., Birmingham—Southern Cement Co., Chamber of Commerce Building, plans installation of electric power equipment in connection with rebuilding portion of mill at North Birmingham, recently destroyed by fire. Loss estimated close to $100,000.

Ark., Augusta—City Council has plans under way for expansion in municipal power plant to double present capacity. Installation will include a 500-kw. Diesel engine-generator unit and accessory equipment. Cost reported about $45,000.

Calif., Alameda—Bureau of Yards and Docks, Navy Department, Washington, D. C., will receive bids until Sept. 20 for boilers and auxiliary equipment, forced and induced-draft fans, pumps and accessories, combustion control apparatus, incinerator, air compressors, gasoline engine-driven generator unit, piping and accessory equipment for installation in power plant at naval air station, Alameda (Specifications 8619).

Conn., East Hartford—United Aircraft Corporation, Pratt & Whitney Division, South Main Street, plans installation of power equipment in new one-story plant addition for airplane engine-testing service. Entire project will cost about $100,000.

Fla., Pensacola—Board of Port Commissioners, J. T. Wright, chairman, is considering new cold storage and refrigerating plant in connection with fruit terminal and distributing building on waterfront. Cost estimated about $250,000, with equipment.

Ill, Chicago—Eastman Kodak Co., Kodak Park, Rochester, N. Y., plans installation of electric power equipment in new three-story and basement branch on Prairie Avenue, near Seventeenth Street, Chicago. Entire project will cost about $500,000. Schmidt, Garden & Erikson, 104 South Michigan Avenue, Chicago, are architects.

Ind., Indianapolis—Hecker Products Corporation, 1437 West Morris Street, plans installation of electric power equipment in new three-story and basement addition to polish-manufacturing plant. Entire project will cost over $100,000. Company is affiliated with Best Foods, Inc., 88 Lexington Avenue, New York, N. Y. Lockwood, Greene Engineers, Inc., 30 Rockefeller Plaza, New York, is engineer.

Ky., Spottsville—Tri-States Refineries, Inc., plan installation of power equipment in connection with expansion and improvements in local oil refining plant, to provide increase in crude oil-handling capacity by about 500 bbl. per day. Cost estimated over $85,000. A. J. Slagter, Sr., is general manager.

La., Morgan City—City Council has p'ans under way for expansion and improvements in municipal electric power plant and waterworks station, including installation of additional equipment. A bond issue of $110,000 has been authorized. Proposed to begin work soon. Joseph Evans is city engineer, in charge.

La., Shreveport—Coca-Cola Bottling Co., Shreveport, plans installation of power equipment in new one and two-story bottling plant at 275 Stoner Avenue. Entire project will cost close to $300,000. Work will begin early in the fall. Jesse M. Shelton, Bona-Allen Building, Atlanta, Ga., is architect.

Md., Baltimore—Rustless Iron & Steel Corporation, 3400 East Chase Street, plans installation of electric power equipment in new additions to local mill. Work is scheduled to begin at once. Entire project will cost about $1,300,000, and appropriation in that amount has been authorized.

Mich., Wayne—Stinson Aircraft Corporation, Wayne, plans installation of electric power equipment in new addition to airplane-manufacturing plant. Entire project will cost close to $100,000. Albert Kahn, Inc., New Center Building, Detroit, Mich., is architect and engineer.

Minn., Moorhead—Water and Light Board, Fred Wensel, president, has plans in progress for expansion and improvements in municipal electric power plant, including installation of new 3000-kw. turbine-generator unit and auxiliary equipment, switchboard, instruments and accessory equipment. Cost about $100,000. Proposed to carry out work early in 1940.

Mo., Kansas City—C. F. Downey Box Co., Fourteenth and Iron Streets, plans boiler house in connection with expansion in paper box manufacturing plant, including one-story addition, 50 by 196 ft. Electric power equipment will be installed for factory operation. Entire project will cost over $65,000. Charles A. Smith, Finance Building, Kansas City, is architect.

Mo., Nevada—City Council is considering new municipal electric power plant, using Diesel engine-generator units with capacity of about 1500 kw., and accessories. Also for new electrical distribution system. Entire project is estimated to cost about $450,000. William Spann, Interstate Building, Kansas City, Mo., is consulting engineer.

N. Y., New York—Consolidated Edison Co., 4 Irving Place, has filed plans for expansion and improvements in steam-electric generating station on block bounded by First Avenue, Thirty-ninth and Fortieth Streets, and East River, to include installation of new turbine-generator unit, high-pressure boilers and auxiliary equipment. Cost about $1,000,000.

Ohio, Cincinnati—Streitmann Biscuit Co., Twelfth Street and Central Parkway, Cincinnati, plans installation of power equipment, traveling ovens, conveyors and other mechanical equipment in new two-story baking plant in Mariemont district, near Cincinnati, where tract of 15 acres of land has been acquired. Entire project will cost close to $2,000,000. John H. Deeken, 800 Broadway, Cincinnati, is architect. Company is a subsidiary of United Biscuit Co. of America, Inc., 1041 West Harrison Street, Chicago, Ill.

Ohio, Painesville—Clifton Products, Inc., care of Robert E. Windecker, 308 West Washington Street, Painesville, recently organized by Mr. Windecker and brothers, Charles Windecker, River Drive, Painesville, plans installation of electric power equipment in new chemical-manufacturing plant on site near city. A boiler house will be built. Entire project will cost approximately $85,000. Work will begin at once.

Pa., Coudersport—Abbott Dairies, Inc., Thirty-first and Chestnut Streets, Philadelphia, Pa., plans of power equipment in new dairy products manufacturing plant at Coudersport. A central gas-fired heating system will be installed. Entire project will cost close to $100,000. Clarence E. Wunder, Architects' Building, Philadelphia, is architect. Proposed to begin work soon.

Pa., Philadelphia—Bureau of Yards and Docks, Navy Department, Washington, D. C., has secured an appropriation of $200,000 for extensions and improvements in power plant at navy yard, Philadelphia, including installation of additional equipment. Plans are in progress and bids are scheduled to be asked soon.

Pa., Philadelphia—Naval Aircraft Factory, Navy Department, Philadelphia, plans installation of electric power equipment in connection with plant expansion and improvements. Total appropriation of $2,000,000 has been authorized for project. Bids will be asked soon by commanding officer for different features of work.

Texas, Corpus Christi—Central Power & Light Co., San Antonio, Tex., plans new steam-electric generating plant at Corpus Christi, to be operated in conjunction with present station at that place. Installation will include steam turbine-generator units, high-pressure boilers and auxiliary equipment. Estimates of cost are being made.

Texas, Midland—Shell Oil Co., Inc., Shell Building, St. Louis, Mo., plans new natural gasoline plant in vicinity of Midland, including power house, compressor station, welded steel pipe lines, steel tank storage facilities and other structures. Plant will be equipped for processing about 30,000,000 cu. ft. of gas per day. Entire project will cost over $1,000,000.

Wash., Tacoma—Water Department, W. A. Kunigk, superintendent, plans early call for bids for four 3500-gal. per min. capacity vertical pumping units and accessories, for installation in municipal pumping station to be constructed at South Tacoma. Also for switchboard and auxiliary electric equipment for same pumping plant, automatic gates, etc. At same time bids will be asked for two deep-well pumping units with combined rating of 8400 gal. per min.

W. Va., Follansbee—Follansbee Brothers Co., Third and Liberty Streets, Pittsburgh, Pa., plans installation of electric power equipment in proposed new additions to steel mill at Follansbee. Entire project will cost about $1,250,000. Financing is being arranged through RFC.

Wis., Merrillan—Village Council plans reconstruction and improvements in municipal hydroelectric power plant. Cost estimated about $30,000. G. L. Van Fleet Co., Dubuque, Iowa, is consulting engineer.